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OPERATING AND MAINTENANCE INSTRUCTIONS FOR

DC VOLTAGE STANDARD

MODEL 303

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COHU
ELECTRONICS, INC
KIN TEL DIVISION

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Technical Manual
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OPERATING AND MAINTENANCE INSTRUCTIONS FOR MODEL 303 DC VOLTAGE STANDARD

SERIAL NUMBERS 1-0001 THROUGH 1-0145

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COHU ELECTRONICS, INC., Kin Tel Division
5725 Kearny Villa Road, Box 623, San Diego, California, 92112

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Section I
GENERAL DESCRIPTION

1-1 INTRODUCTION

The KIN TEL Model 303 DC Voltage Standard is a precision voltage source of adjustable positive or negative DC voltages.

1-2 APPLICATIONS

In the calibration of digital voltmeters accuracy exceeding the overall accuracy of conventional standard laboratory setups employing standard cells, volt boxes and potentiometer or universal ratio set is achievable.

1-3 DESCRIPTION

1-4. GENERAL. The Model 303 (Figure 1-1) is a rack- or table-mount unit designed for operator convenience. Seven direct-reading dials allow selection of a desired DC voltage output in 1-microvolt steps from zero to over 11 volts, in 10-microvolt steps from zero to over 110 volts and in 100-microvolt steps from zero to over 1100 volts. Voltage range, output current, and overload control are selectable by three mode selector switches. The VOLTAGE RANGE switch selects the three decade voltage ranges and controls the illuminated positioning of the decimal point indication lamps. The output current is limited in four discrete steps by the CURRENT LIMIT switch. Protection from both over-current and over-voltage is provided by the three-position OVER LOAD switch. The DC switch applies voltage to the output terminals. On the front panel are two terminals for supplying current to the load, two terminals for measuring the load voltages, and either one or two shield terminals. This set of terminals is duplicated at

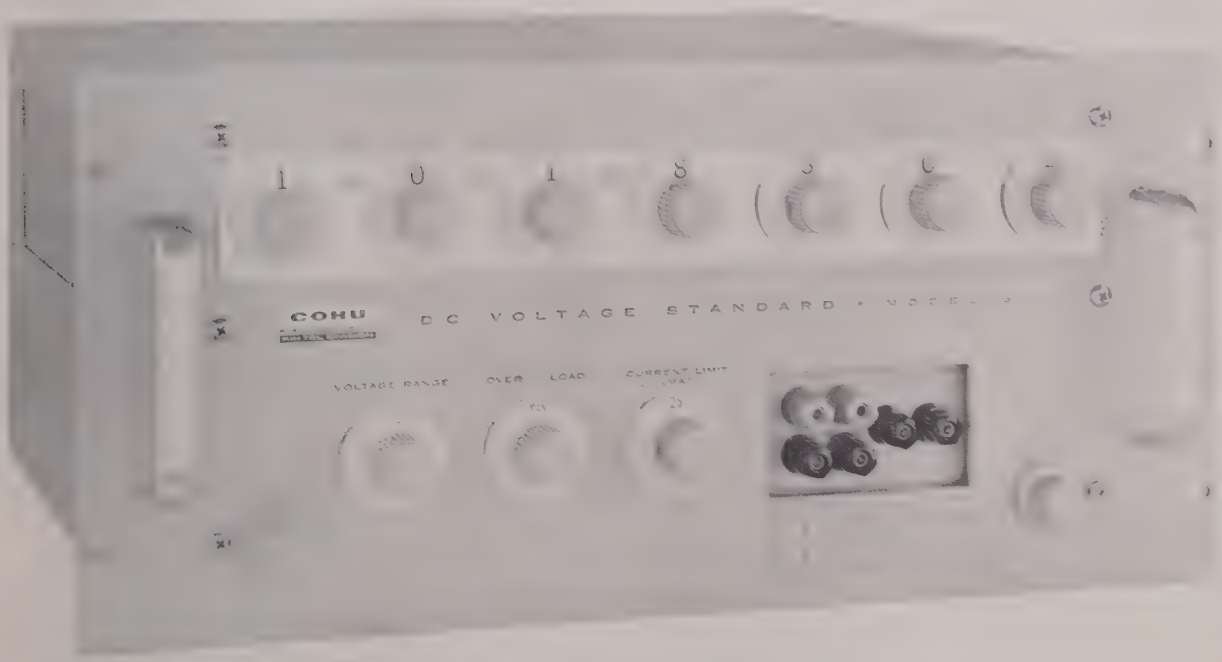


Figure 1-1. Model 303 DC Voltage Standard

the rear of the instrument. Individual panel lamps indicate AC and DC switch conditions and presence of overload.

The three-wire AC line cord enters the rear of the unit adjacent to the fuse holder. The ventilating fan filter is a permanent, washable, screen-mesh type.

1-5. RESISTANCE DECADE. The resistance decade uses precision wire-wound resistors in the seven, 11-position controls to achieve a high resolution of output voltage adjustment. The controls are arranged to permit the same voltage selection in two or more ways. This permits a linearity self-check feature for all ranges. The position X setting on one dial provides an output voltage equal to a 1 position setting on the next higher voltage dial. Used in this manner, the resistance decade permits comparison of the same output voltage provided by different range and dial settings. An appropriate program of tests and adjustments enable the precise linearization of the voltage settings.

1-6. CIRCUIT SHIELDING. The Model 303 is encased in three insulated metal enclosures (see legend on instrument front panel). The inner case is connected to the B GUARD terminals on instruments bearing serial numbers 1-0001 through 1-0115; all other instruments are not equipped with B GUARD terminals and the inner shield is permanently connected internally to circuit common (+SAMPLING terminals). A second case enclosing the B GUARD (SHIELD) case is connected to the C GUARD terminals. The outer case is connected to conduit ground through the green third wire in the AC line input cable. The inherent capacitance between the instrument circuits and the inner enclosure, and between enclosures, is approximately 0.004 microfarads. This shielding system permits operation of the internal circuitry with up to a ±1500-volt potential difference between inner shield and the outer case without undesirable effects. With this effective shielding system, errors due to common mode voltages having frequencies over 60 cps are practically negligible.

1-7 SPECIFICATIONS

Table 1-1 lists the electrical performance specifications of the Model 303 DC Voltage Standard. Physical dimensional specifications are illustrated in Figure 1-2.

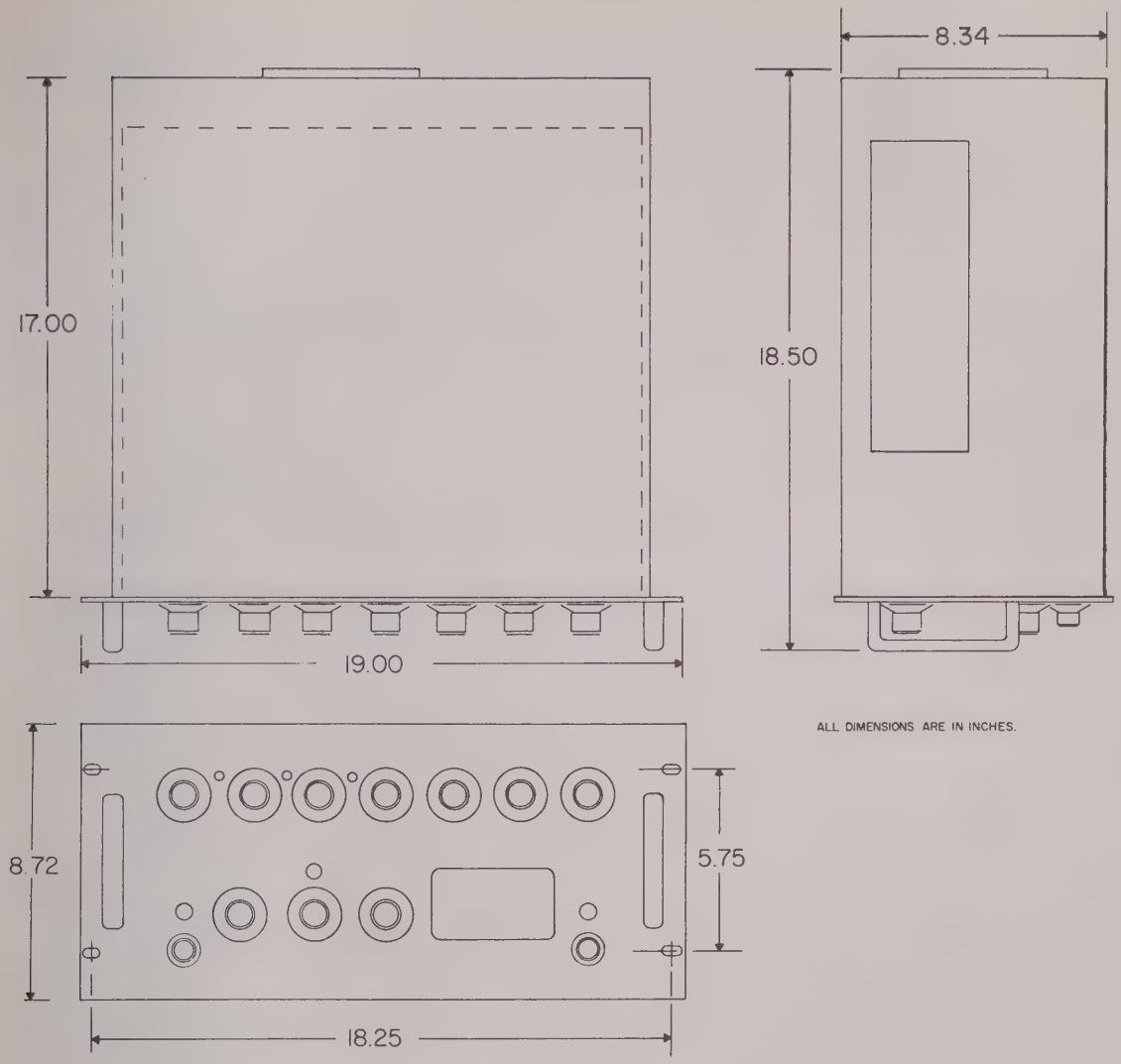


Figure 1-2. Dimensions and Outline

Table 1-1. Model 303 Electrical Specifications

OUTPUT VOLTAGE	0 to ±1111.1110 volts in three ranges: 10-volt range - 0 to ±11.111110 in 1 μv steps 100-volt range - 0 to ±111.11110 in 10 μv steps 1000-volt range - 0 to ±1111.1110 in 100 μv steps
OUTPUT CURRENT	0 to 25 MA in four ranges: 0-5 MA, 0-10 MA, 0-15 MA, 0-25 MA
ACCURACY	10-volt range - 0.01% or 25 μv 100-volt range - 0.01% or 50 μv 1000-volt range - 0.01% or 100 μv
STABILITY (constant line voltage and ambient temperature)	<0.1 cps: 10-volt range - <0.0025% or 13 μv/8 hours <0.005% or 25 μv/30 days 100-volt range - <0.0025% or 25 μv/8 hours <0.005% or 50 μv/30 days 1000-volt range - <0.0025% or 25 μv/8 hours <0.005% or 50 μv/30 days
NOISE AND HUM	0.1 - 10 cps: all ranges - ≤10 μv RMS 10 - 750 cps: 10-volt range - <40 μv RMS 100-volt range - <70 μv RMS 1000-volt range - <100 μv RMS
REJECTION OF COMMON MODE INTERMODULATION PRODUCTS (DC offset against RMS AC between C Guard and outer case)	10^{-6} at 60 cps
SOURCE IMPEDANCE	0.001 ohm and $0.0004E_{out}$ maximum
LOAD REGULATION	0.001% or 25 μv no load to full load
LINE REGULATION	0.001% or 10 μv for 10% line change
TEMPERATURE COEFFICIENT	<5 parts/million/°C from +15°C to +35°C
POWER INPUT	105 to 125 or 210 to 250 volts, 50 or 60 cps, 125VA
MAXIMUM WARM-UP TIME	15 minutes to 0.01% 30 minutes to complete stabilization

Section II
OPERATION

2-1 INSTALLATION

The Model 303 may be mounted in a standard 19-inch rack or used as a cabinet unit. Care should be taken during installation to ensure that a minimum of one inch is allowed for adequate ventilation between the rear of the unit and adjacent wall or obstacle.

WARNING

Voltages of sufficient potential to cause serious shock may be present at the output terminals. Ensure that the DC switch on the front panel is OFF when the unit is not in use or when making electrical connections to the terminals.

2-2 PRELIMINARY CHECKS

Although the Model 303 is well packed and unlikely to be damaged during shipment, it is advisable to check it soon as possible after receipt. Inspect the unit for any visible signs of damage and then make a performance check in accordance with the information and instructions in paragraphs 2-3 through 2-9. Refer to Figure 2-1 and Table 2-1 for use of the operating controls. If desired, a more thorough test of the unit can be made by referring to paragraphs 4-9 and 4-10.

2-3 TERMINAL CONNECTIONS

The Model 303 can be used as a floating or grounded, two or four-terminal instrument. Either positive or negative output voltages can be supplied depending on terminal connections. Connections may be made at the front or the rear terminals but must never be made at both. For two-terminal connections refer to paragraph 2-4; for four-terminal connections refer to paragraph 2-5.

2-4. TWO-TERMINAL OUTPUT. Positive, two-terminal output to nearby loads is achieved by connecting the terminals as illustrated in Figure 2-2. Negative, two-terminal output to a nearby load is achieved by connecting the terminals as shown in Figure 2-3. Floating two-terminal output voltage to a nearby load is permitted by connecting terminals as illustrated in Figures 2-2 and 2-3 and omitting ground connection.

When the instrument is not equipped with B GUARD terminals, the C GUARD terminal connection should be as shown in Figure 2-2 for a positive output; for a negative output, Figure 2-3, the C GUARD terminal should be connected to the +SAMPLING terminal.

2-5. FOUR-TERMINAL OUTPUT. When using the four-terminal output feature of the Model 303, two terminals furnish the current for the load and two terminals are used to sample the voltage across the load. The four-terminal output is normally used where distant loads are required. By sampling the voltage at the load, no error voltage between the instrument OUTPUT terminals and the voltage across the load is caused by the IR drop due to the external leads. For positive or negative output voltage for distant loads, connect the terminals as shown in Figures 2-4 and 2-5.

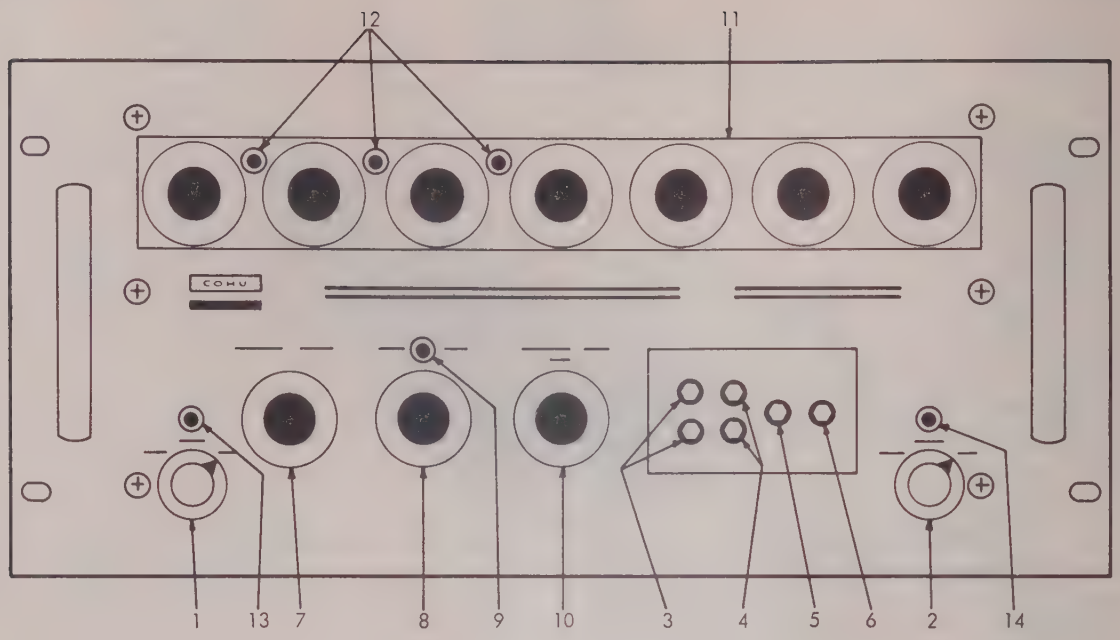


Figure 2-1. Operating Controls (See Table 2-1)

Table 2-1. Operating Controls (Keyed to Figure 2-1)

NOMENCLATURE	DESCRIPTION	FUNCTION
AC switch (1, Figure 2-1)	Two-position, OFF-ON	AC power to unit
DC switch (2)	Two-position, OFF-ON	DC power to output terminals
+ and - OUTPUT terminals (3)	Terminal post	Output supply to load (paragraph 2-3)
+ and - SAMPLING terminals (4)	Terminal post	Remote sampling (paragraph 2-3)
B GUARD terminal (5)	Terminal post (serial numbers 1-0001 through 1-0115 only)	Common, connect to + SAMPLING (paragraph 2-3)
C GUARD terminal (6)	Terminal post	Shield (paragraph 2-3)
VOLTAGE RANGE switch (7)	Three-position, 10, 100, 1000	Output voltage range selection
OVER LOAD switch (8)	Three-position, MAN, AUTO, RESET, spring-return between MAN and RESET	Circuit protection

Table 2-1. Operating Controls (Keyed to Figure 2-1) (Contd)

NOMENCLATURE	DESCRIPTION	FUNCTION
OVER LOAD lamp (9)	Indicator, overload controlled. Illuminated until extinguished by setting OVER LOAD switch to RESET and returning to MAN. Automatically extinguished with switch in AUTO position	Indicates overload condition (over-current or over-voltage)
CURRENT LIMIT (MA) switch (10)	Four-position, 5, 10, 15, 25	Output current limit selection
Output Voltage switches (11)	7-eleven-position dial set	Output voltage setting (depends on VOLTAGE RANGE switch setting)
Decimal indication lamps (12)	Indicator, VOLTAGE RANGE switch controlled. Individually illuminated depending on switch position.	Output voltage readout decimal indication
AC lamp (13)	Indicator	Illuminates when AC power is present in unit
DC lamp (14)	Indicator	Illuminates when DC power is present at output terminals

When the instrument is not equipped with B GUARD terminals, the cable shield lead, shown connected to the B GUARD terminal in Figures 2-4 and 2-5, should be connected to the +SAMPLING terminal.

2-6. OUTPUT CABLES. For convenience in making external load connections, two models of output cables are available as accessories to the Model 303. The Model 303-11 and 303-12 output cables are of four-conductor, dual shielded construction (see Figure 2-6). The shields are made of a conductive vinyl which provides a continuous shield. However, this material is highly resistive and therefore requires the use of a drain

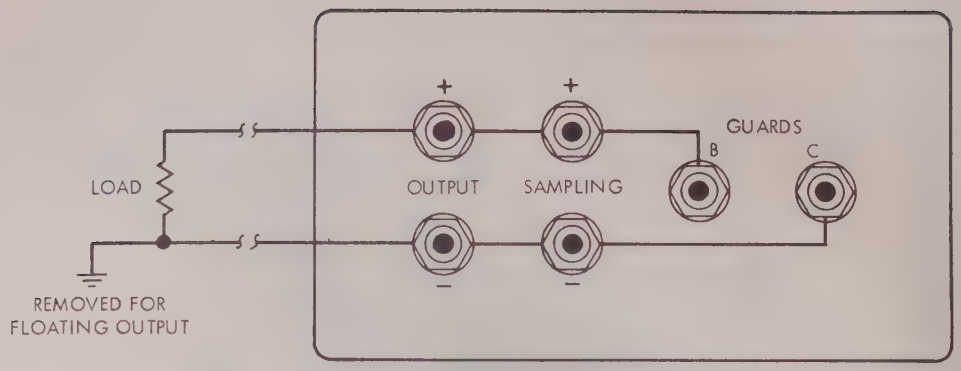


Figure 2-2. Positive, Two-Terminal Output Connections

lead. The drain lead is a small copper wire wound loosely around the cable making contact along the inside of the conductive vinyl shield. This arrangement reduces the resistance per unit length of the shield. The Model 303-11 provides a spade lug termination at each end of the six-and-one half foot cable, while the Model 303-12 permits termination selection at one end and spade lug termination at the other. Leakage resistance between conductors is 100,000 megohms (minimum) per foot. Voltage rating between conductors, between shields, and between conductors and shields, is 1000 volts RMS.

2-7 POWER CONNECTION

After the output terminals have been properly connected, check the front panel controls to make sure that the AC and DC power switches are OFF. Connect the three-conductor power cable to a source of 105 to 125 volts, 60 cycles. Use a three-prong adapter when operating the instrument from a two-contact convenience outlet. Ground the unit externally with the green pigtail on the adapter.

2-8 OPERATING PROCEDURES

The following procedures involve

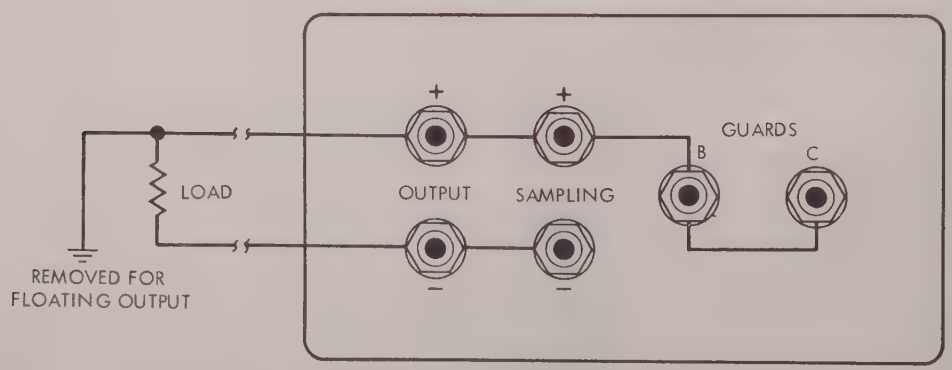


Figure 2-3. Negative, Two-Terminal Output Connections

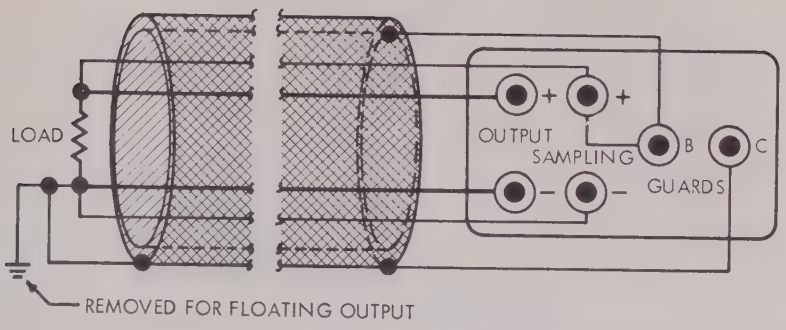


Figure 2-4. Positive, Four-Terminal Output Connections

arbitrary control settings in order to familiarize the operator with the DC Voltage Standard. These procedures are applicable for operational use and vary only in the values of voltage and current limit. Refer to Figure 2-1 for control locations.

WARNING

Prior to connecting a load to the DC Voltage Standard ensure that the DC switch is OFF and connections are correct. Voltages which constitute a serious shock hazard can be present at output terminals with the DC switch ON.

a. Set VOLTAGE RANGE switch to 10.

b. Set all seven output voltage switches to 0.

c. Set OVER LOAD switch to MAN.

d. Set CURRENT LIMIT (MA) switch to 5.

e. Set AC switch to ON. The AC lamp, the OVER LOAD lamp, and the decimal lamp for the 10 volt range (extreme left) will illuminate. The ventilating fan will operate.

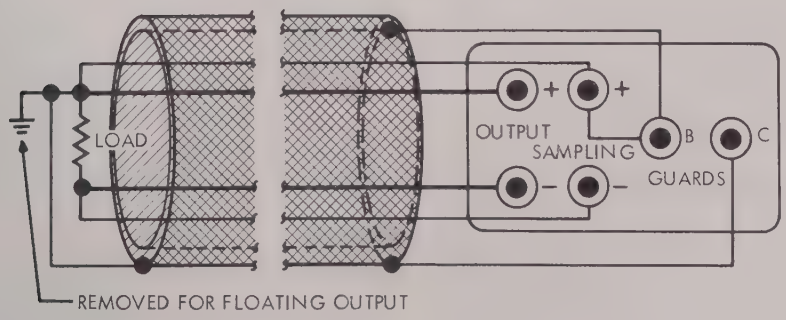


Figure 2-5. Negative, Four-Terminal Output Connections

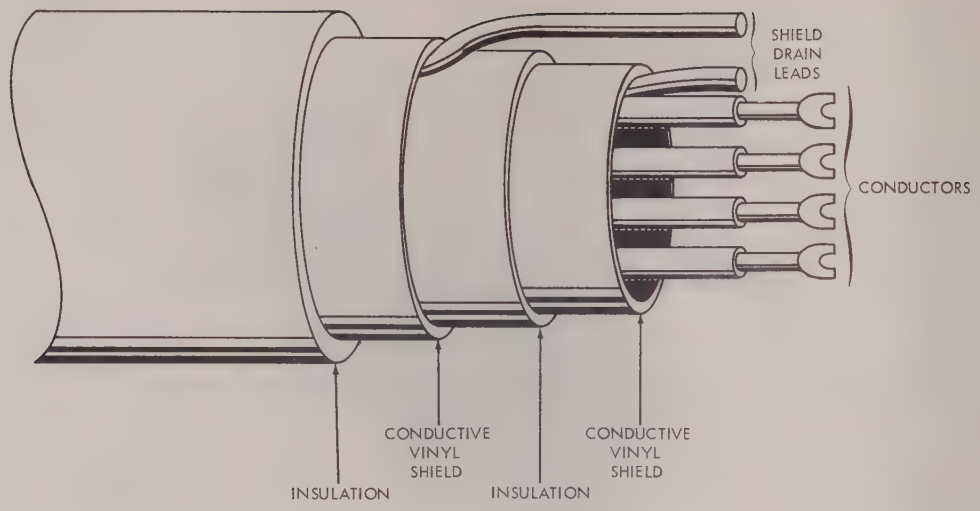


Figure 2-6. Output Cable

NOTE

Allow approximately 45 seconds for circuit voltages to stabilize.

f. Turn OVER LOAD switch to RESET; allow switch to return to MAN. The OVER LOAD lamp will extinguish.

NOTE

If OVER LOAD lamp remains illuminated repeat the previous step. Failure of the lamp to extinguish could mean lack of unit warm-up time or possible malfunction. Refer to paragraph 4-11 if condition persists.

g. Set DC switch to ON. The DC lamp will illuminate. If the lamp extinguishes, check for possible overload or improper connection.

h. Output voltage and range controls now may be set to provide DC voltage output from 0 to 1111.1110 volts.

i. Return DC switch to OFF during unit standby.

2-9 VALIDATION

A simple check of the Model 303 output voltage against setting linearity may be made by using a KIN TEL Model 501B Digital Voltmeter, or equivalent, as a readout device.

NOTE

Readout devices not having the automatic range change features of the Digital Voltmeter referenced, must have voltage range selectors positioned to the appropriate scale before measurement.

Set various output voltages and compare the settings with the voltages indicated by the readout device. Also, compare the same voltage by using different range and voltage settings.

Section III
THEORY OF OPERATION

3-1 GENERAL THEORY OF OPERATION

The KIN TEL Model 303 DC Voltage Standard is composed of seven major sections; the high voltage power supply, the output tube, the reference unit, the voltage range and output voltage switches, and the three control amplifiers. High voltage AC from the power transformer is applied to the high voltage power supply where the voltage is rectified to approximately 1400 volts DC. This DC voltage is applied directly to the plate of the output tube. The voltage across the output tube is controlled by a signal applied to its control grid by the DC output amplifier. (See Figure 3-1.) This controlled voltage is applied through a current sensing network to the + OUTPUT terminal of the instrument. The - OUTPUT terminal is connected directly to the negative side of the high voltage power supply. The output voltage of the instrument is determined by settings of the voltage range and the output voltage switches. The reference unit maintains an extremely stable current through the range and decade resistors. The output voltage of the instrument is determined by this constant current through the resistors selected by the voltage range and output voltage switches. The summing junction is normally at zero potential with respect to circuit common (+ SAMPLING terminal). A change in the output voltage dial settings produces a change in the decade resistance, and the instan-

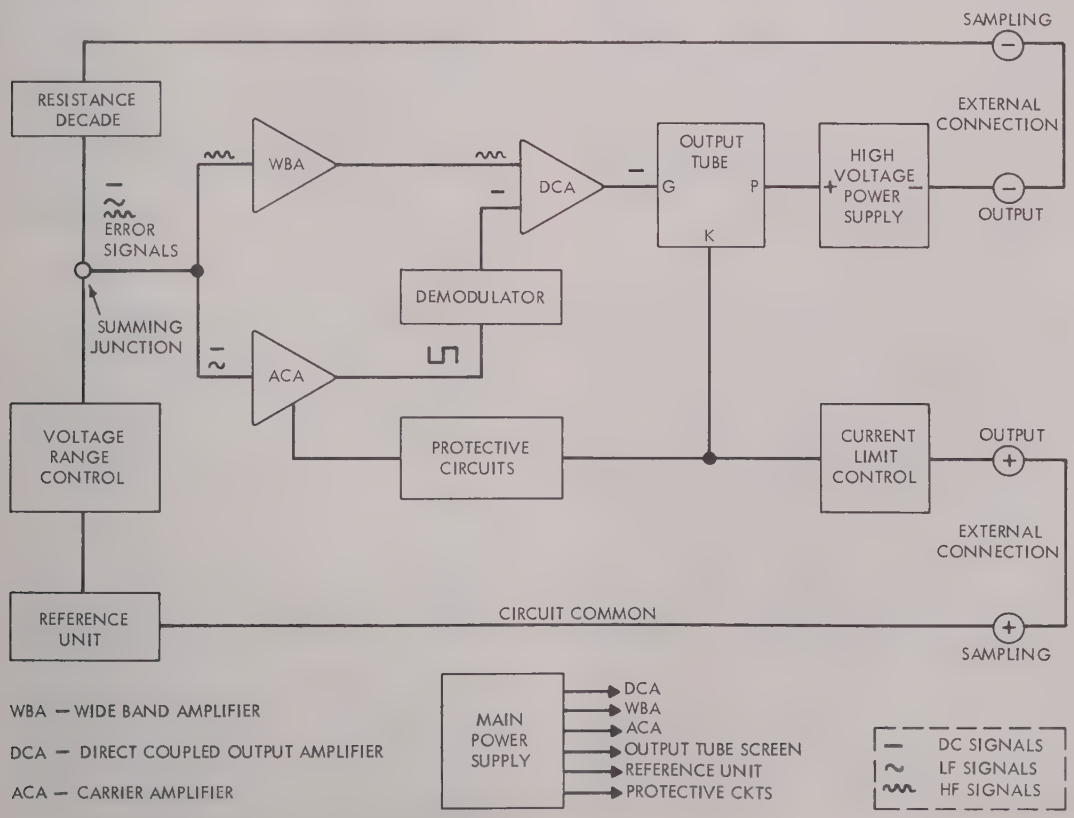


Figure 3-1. Model 303, Block Diagram

taneous change in voltage appears as an error signal at the summing junction. This signal is amplified by the three amplifiers and applied to the control grid of the output tube, which changes the output voltage and hence the voltage across the resistance decade, returning the summing junction to zero. The loop gain, 150 db, is sufficient to make the residual error negligible. With the summing junction again at zero potential the output voltage of the instrument will have assumed the magnitude of the new setting of the output voltage dials.

3-2 DETAILED THEORY OF OPERATION

The theory of operation of the DC Voltage Standard is discussed in detail in the following paragraphs under the heading of power supplies, resistance decade and range switching, carrier amplifier, demodulator, wideband amplifier, DC output amplifier, output tube, protective circuits, and reference unit. The discussion is supported by simplified schematic diagrams; complete schematic diagrams are contained in Section IV.

3-3. POWER SUPPLIES. Two DC power supplies are utilized to furnish the operating voltages for the DC Voltage Standard. The high voltage power supply provides unregulated +1400 volts to the plate of the output tube. The main power supply provides a wide range of positive and negative voltages to the dynamic components of the DC Voltage Standard. The main power supply provides the following voltages:

a. +380 volts for the direct coupled output amplifier (DCA) and protective circuits.

b. +320 volts for the plate circuits of the wideband amplifier (WBA).

c. +240 volts for plate and screen circuits of the carrier amplifier (ACA) and wideband amplifier.

d. +125 volts for the output tube screen grid.

e. +20 volts for the output relay (K901) operation.

f. +22 volts for the reference unit.

g. +12 volts for the DC filaments.

h. -380 volts for the DCA. This voltage is also divided to furnish the negative voltages for the protective circuits.

All AC voltages are supplied from taps on the secondary winding of the power transformer. The following voltages are supplied: 1000 volts to the high voltage DC supply, and 650 volts, 175 volts, 115 volts, and 6.3 volts AC to the main power supply. The 115 volts and 6.3 volts are supplied at two current ratings; 115 volts at 0.04 and 0.25 amperes and 6.3 volts at 1.2 and 2 amperes.

3-4. RESISTANCE DECADE AND RANGE SWITCHING. Due to the temperature controlled environment of the reference unit, and the arrangement of the switching circuits, the current supplied by the reference unit is constant regardless of the position of the VOLTAGE RANGE switch. The simplified schematic diagram illustrated in Figure 3-2 shows that whatever the position of the switch, two of the three resistors are always connected across the reference unit and one resistor is connected to the resistance decade via the summing junction. The only change is in the output current flowing through the resistance decade. The summing junction is normally at zero potential

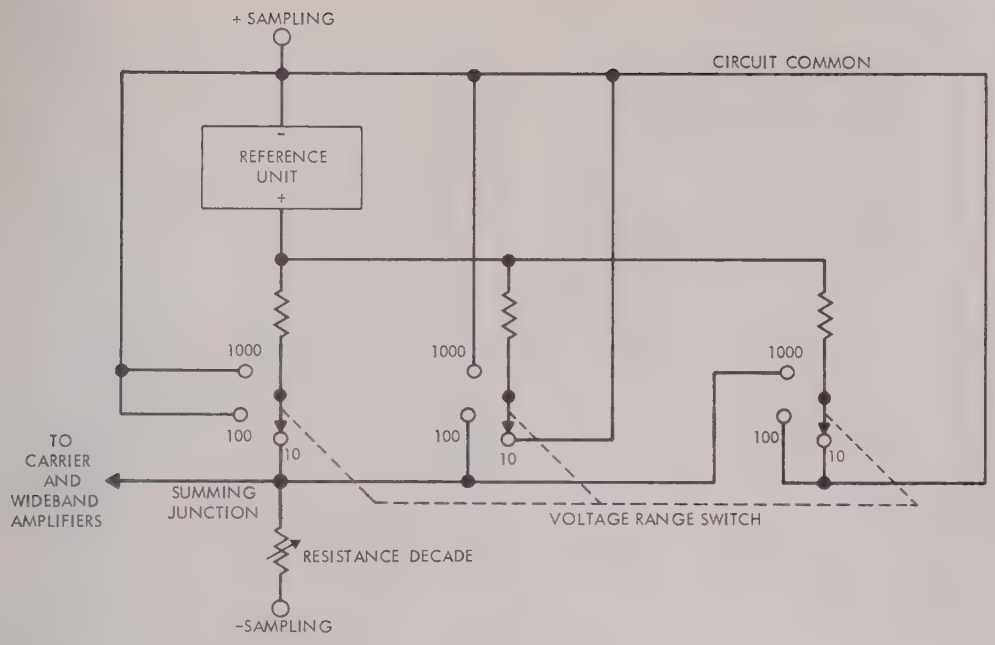


Figure 3-2. Range Control Switching, Simplified Schematic Diagram

but a change in output current, due to changing the position of the VOLTAGE RANGE or output voltage controls, causes the potential to change. This transistory change in voltage at the summing junction is applied as an error signal to the carrier and wideband amplifiers.

3-5. CARRIER AMPLIFIER. The carrier amplifer acts upon DC and lower frequency signals and mainly consists of the chopper, D801, and three amplifier stages. A simplified schematic diagram of the circuits is shown in Figure 3-3.

An error signal, caused by a change in output voltage of the instrument, is applied via resistor R803 to pin 1 of the chopper. The error signal is converted to pulsating DC at a 60-cycle rate, and coupled by C210 to the grid of V201B. The signal is amplified by V201B and coupled by C211 to the grid of V203. From the V203 plate, the amplified signal is coupled by C214 and R228 to the control grid of V204. From the plate of V204, the signal is coupled by C316 to the demodulator. A portion of the signal at the output of V203 is demodulated and applied to the control-grid circuit of V202 and serves to stabilize the wideband amplifier and reduce overload recovery time.

3-6. DEMODULATOR. The basic circuit of the demodulator is shown in Figure 3-4. The demodulator consists of a circuit for phase sensitive detection of the output signal of the carrier amplifier. Diodes CR305 and CR306 are arranged in a keyed clamp circuit. When the diodes conduct the diode junction is at the same voltage as the junction of R356 and R357. The voltage at the diode junction is thus clamped at the reference point on the waveform in Figure 3-4 indicated by the dotted line and asterisk. The demodulated carrier amplifier output signal is applied through R348 to the grid of the triode section of V303, the first stage in the DC output amplifier. The network comprised of R350 through R354 supplies proper biasing for the V303 grids (see Figure 3-6).

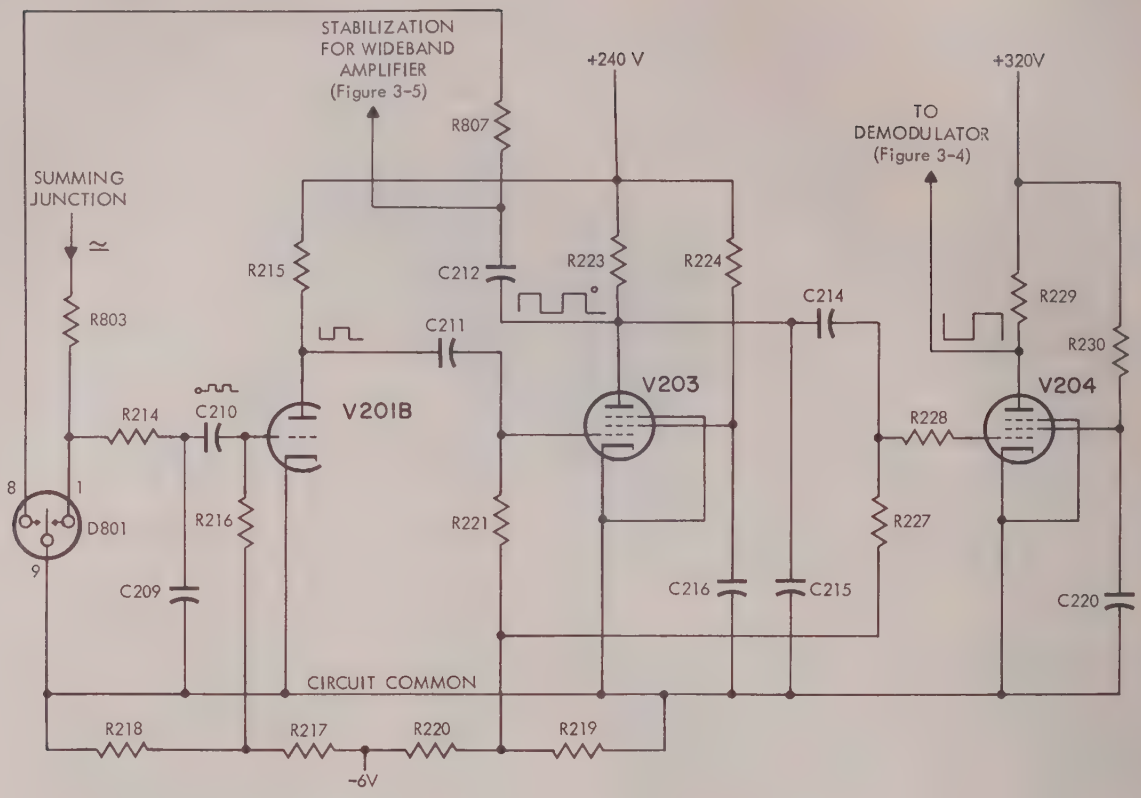


Figure 3-3. Carrier Amplifier, Simplified Schematic Diagram

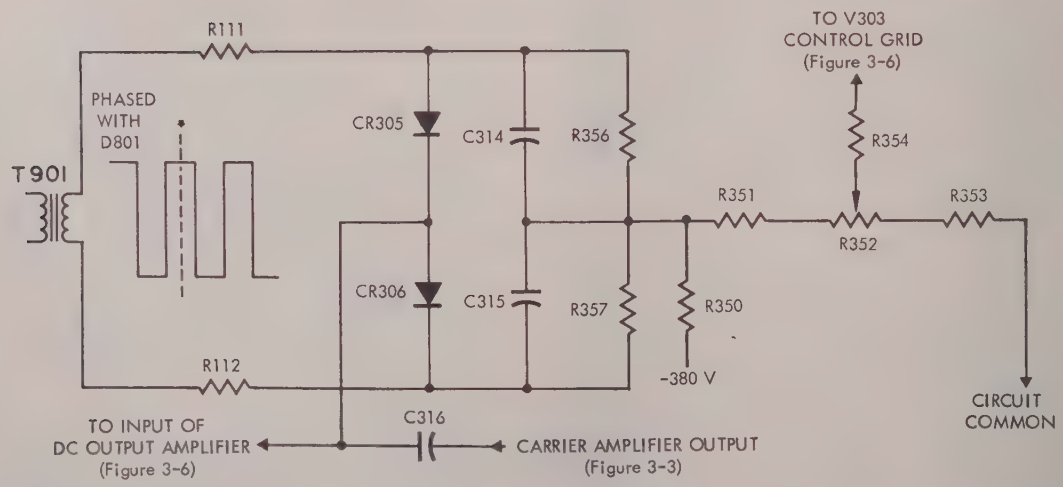


Figure 3-4. Demodulator, Simplified Schematic Diagram

3-7. WIDEBAND AMPLIFIER. High frequency components of the summing junction input signal to the amplifier are applied through C201 to the grid of V201A, the first stage in the wideband amplifier. Figure 3-5 is a simplified schematic diagram showing the basic circuit configuration of the wideband amplifier. The amplified signal is coupled from V201A through C205 and an overload compensation network, R209 and C206, to the grid of V202. One demodulated signal from the carrier amplifier is also applied to the grid circuit of V202. This signal is applied through the network consisting of R206, R222, neon bulb DS201, and R208, to stabilize the wideband amplifier. Under overload conditions the magnitude of the signals applied to the network increases. As a transient overload occurs, a signal from the carrier amplifier ionizes the neon bulb which reduces the resistance between pin 8 of the chopper and the grid of V202. This resulting increased transmission reduces the time required for return to normal operation. The neon bulb deionizes as the signal levels return to normal. The amplified signal from V202 is coupled through C309 to the grid of the triode section of V303, first stage in the DC output amplifier, combining with the demodulated signal from the carrier amplifier, and through C308 to the grid of V302.

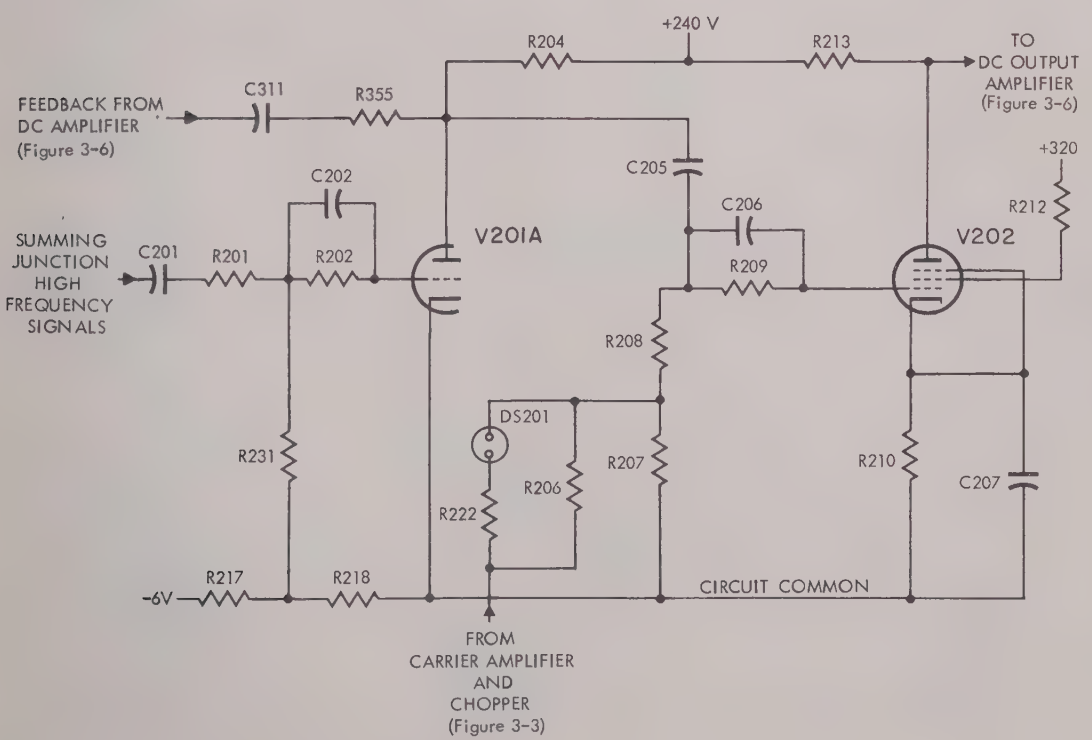


Figure 3-5. Wideband Amplifier, Simplified Schematic Diagram

3-8. DC OUTPUT AMPLIFIER. Figure 3-6 is a simplified schematic diagram of the DC output amplifier. The triode section of V303 is a cathode follower operated between -380 volts and common. The signal is cathode coupled to the pentode section. The signal at the pentode plate of V303 is applied directly to the control grid of the output tube V901. Another signal from the wideband amplifier is coupled through C308 to the control grid of V302, and the output of this cathode follower is coupled through C307 to the control grid of the output tube. At low frequencies the loading effect of cathode follower stage V302 modifies the response of V303. Additionally, the parallel signal path passes high frequency components which are beyond the response of V303.

The V303 pentode section serves as a driver for the output tube at DC and low frequencies, but as frequency increases, gain diminishes until at unity gain the output tube drive signal is applied directly by V302. Note that V303 provides large voltage gain and low input drift with relatively large swing but narrow bandwidth. Tube V303 provides the high frequency component with lower voltage swing capability but much lower output impedance.

An internal negative feedback around the DC output amplifier and the last stage of the wideband amplifier largely determines and stabilizes the transfer function of these stages. Figure 3-5 and Figure 3-6 both show C311 and R355 which are components of the feedback network.

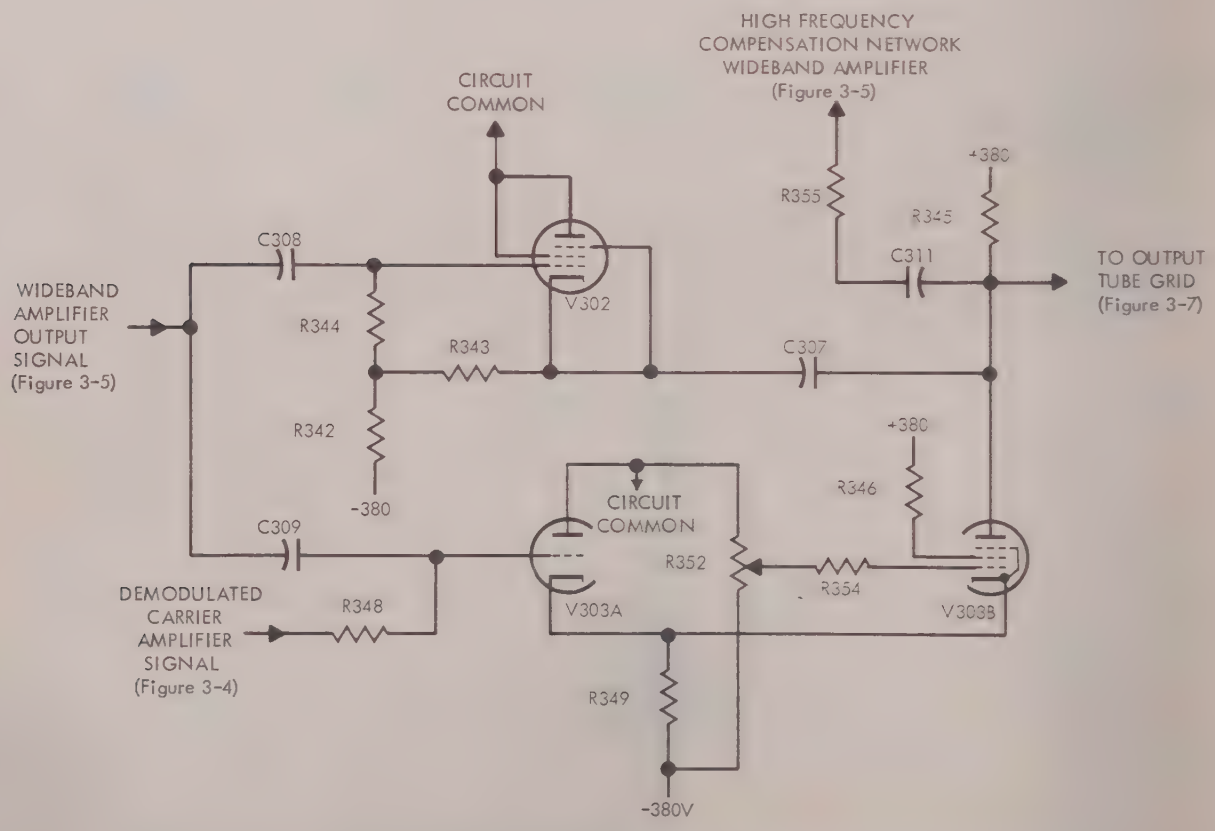


Figure 3-6. DC Output Amplifier, Simplified Schematic Diagram

3-9. OUTPUT TUBE. The circuits for the output tube, V901, are shown in Figure 3-7. It should be noted that this circuitry includes two voltage supplies that are not referenced to circuit common. These are the 1400-volt supply that is applied to the plate of V901 by the high voltage power supply, and the 125-volt supply at the screen grid of V901.

Although the load and plate supply of V901 are transposed, the tube is not used as a cathode follower but as a voltage amplifier. The transposition is possible because the 1400-volt supply is not common to any other circuit, and this permits one terminal (+e) to be common to all amplifiers and to the cathode of V901. This circuit configuration reduces the voltage swing required of the preceding stages to less than a hundred volts rather than over a thousand volts.

The load on the output tube mainly consists of the external load on the instrument in parallel with the voltage range resistors, the resistance decade and its bypass capacitor C903, and the output capacitor C902. Resistors R914 and R915 provide a discharge path for the capacitors. An additional load on V901 is provided by the +380-volt supply and R503 and R504 which prevent the tube cutting off completely when it is not otherwise conducting (that is, when the instrument is not loaded and the output voltage dials are set for zero volts).

The output of the DC output amplifier drives the control grid of the output tube which changes the output voltage, and hence the voltage across the resistance decade, returning the summing junction to zero potential. With the summing junction again at zero potential, the output voltage of the instrument assumes the magnitude to which the output voltage dials have been set.

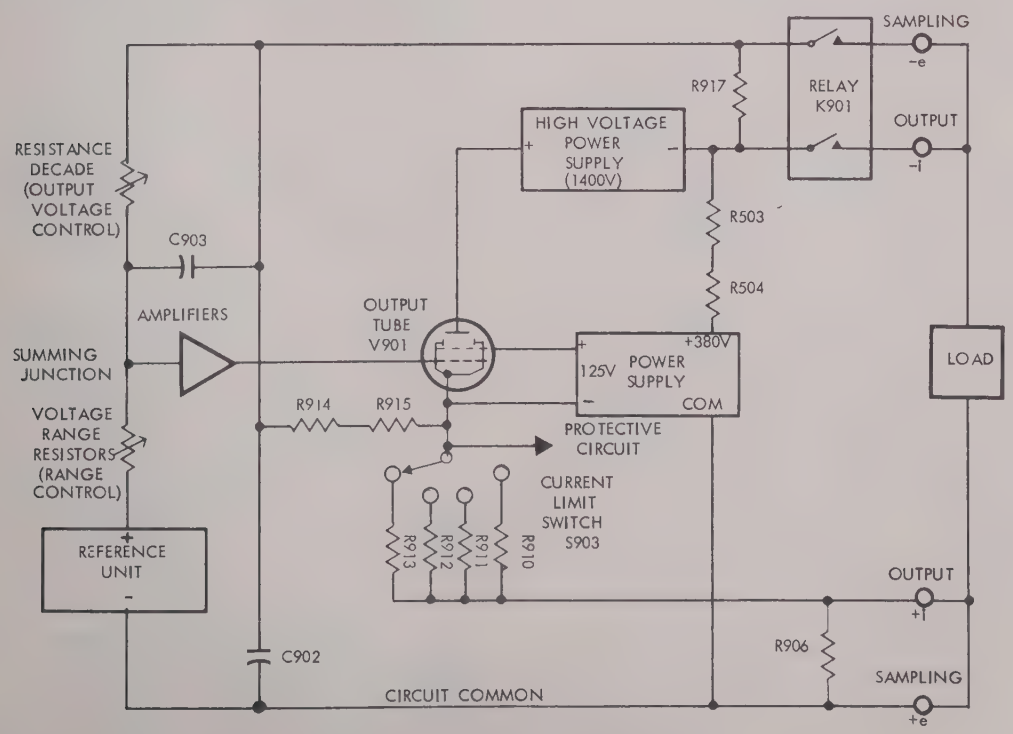


Figure 3-7. Output Tube Circuits

3-10. PROTECTIVE CIRCUITS. The basic function of the protective circuits is to open the negative output terminals in the event of an over-voltage condition (when the output voltage exceeds the voltage indicated by the setting of the output voltage dials) or an over-current condition (when the output current exceeds the limit set by the CURRENT LIMIT switch). During the over-voltage condition, a negative voltage signal cuts off relay tube V301, de-energizing relay K301 and output relay K901. The tube is held at cut-off or caused to conduct by the action of transistor Q305, which is the output transistor of the five-transistor control circuit. Depending upon the OVER LOAD switch position, the protective circuit can return V301 to the conduction state either automatically or by manual reset.

During an over-current condition, excessive voltage drop across the current-limit resistor overcomes the biasing set on the input stage of the protective circuit, which causes changes of state of the transistor circuits. At this point, the signal of Q305 again biases relay tube V301 to cut-off.

The simplified schematic diagram of Figure 3-8, illustrates one of the two types of protective circuits. The output of V203 is coupled through C213 to the cathode of diode CR301. A small amount of back-bias obtained from voltage divider R301 and R303 is applied through R302 to the cathode of CR301 as a holding voltage. This renders the diode non-conductive unless the voltage coupled from V203 plate increases sufficiently to overcome the bias. The grid of V301 is held at a small negative voltage by voltage divider R304 and R306. The cathode of V301 is held close to zero volt by conduction through Q305.

When an over-voltage condition occurs, an error voltage appears at the summing junction and is chopper modulated and amplified by V201B

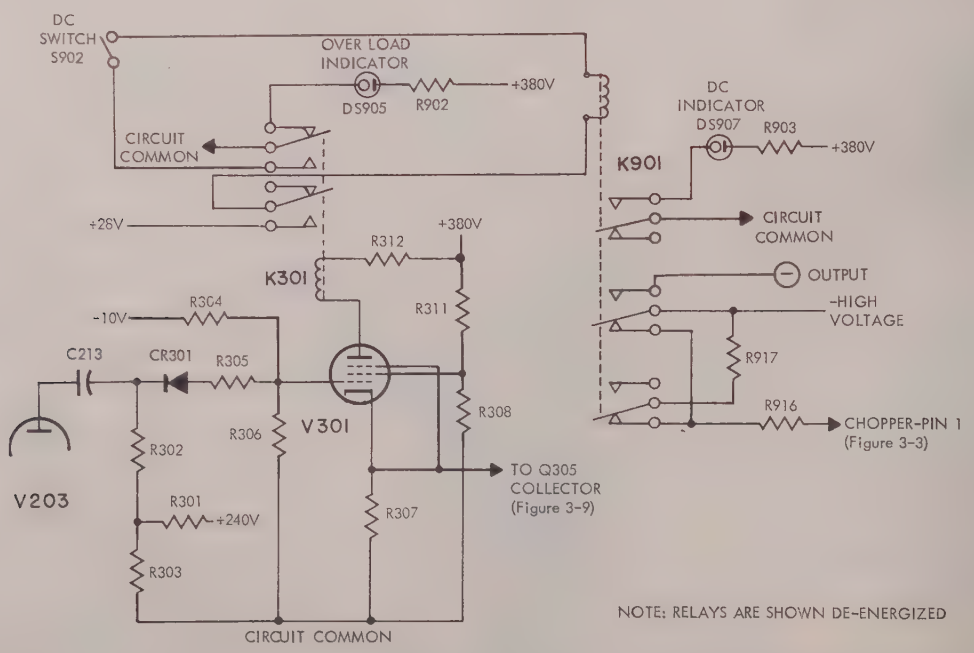


Figure 3-8. Over-Voltage Protective Circuit, Simplified Schematic Diagram

and V203. The negative excursion of the output of V203 is sufficient to exceed the holding voltage on diode CR301 which conducts causing V301 to cut off. At cut-off, V301 de-energizes relay K301 which in turn de-energizes relay K901. When the contacts of relay K901 open, the negative output terminal is disconnected from the circuit.

The increase in V301 plate voltage also increases the potential at voltage divider R309 and R310, which trips the Schmidt trigger circuit, Q301 and Q302, Figure 3-9, changing the state of the flip-flop circuit, Q303 and Q304. The flip-flop then provides increased bias on the cathode of V301 by cutting off the signal normally supplied by Q305.

The over-current protection circuit is illustrated in Figure 3-9. A small amount of voltage is normally developed across the current-limit resistor selected by positioning the CURRENT LIMIT switch. This voltage is applied across R317 and R316 which set the bias voltage for the trigger circuit. Under normal conditions, Q301 is in the conduction or "on" state and Q302 is in the non-conducting or "off" state. If the load current exceeds the set value of the current-limiting resistor, the resultant voltage produced will exceed the bias on the trigger circuit. Q301 will stop conducting and Q302 will start conducting, then once again reverse states producing an output pulse. The pulses produced by the changing states of the trigger circuit are applied to the flip-flop circuit. Under normal conditions Q303 is in the "on" state and Q304 is in the "off" state. Upon receipt of the signals from the trigger circuit, the first stage of the flip-flop, Q303, goes "off", applying a signal to the second stage, Q304, and concurrently to the base of transistor Q305. The output of Q305 is returned to the cathode of V301 and biases the relay tube to cut-off, causing relay K301 to de-energize. The contacts of relay K301 open de-energizing output relay K901 which disconnects the negative output terminal from the circuit.

After the overload condition, normal operation is resumed by either manual or automatic reset. Under manual control, the input to the flip-flop, Q303, sees only the positive pulses from the trigger circuit because of the selective action of CR303. In this case, after switching, Q304 remains in the "on" state until the base is grounded through resistor R314 and RC network R315 and C303 by the action of the OVER LOAD switch S905.

Under automatic control, the input to the flip-flop Q303, sees both the positive and the negative pulses from the trigger circuit since diode CR303 is bypassed by the positioning of the OVER LOAD switch to AUTO. The flip-flop circuit, under this condition, turns "on" and "off" as the positive and negative pulses arrive. When the overload condition is removed, the flip-flop will automatically return to the normal condition with Q303 conducting and Q304 cut off.

3-11. REFERENCE UNIT. The reference unit consists of an electronically controlled oven, and temperature controlled circuits including three Zener diodes and a transistor. The oven is maintained at a temperature of 65 ±5 degrees C and has a temperature stability within 0.1 degree C. The short term stability of the reference unit is better than 10 parts per million and its long term stability is better than 30 parts per million. The inputs to the reference unit are 15V and 25V, 60 cps for the oven, and 22V DC for the reference. The output is 6V DC. Because constant load is provided by the range switching, discussed in paragraph 3-4, the current supplied by the reference is constant.

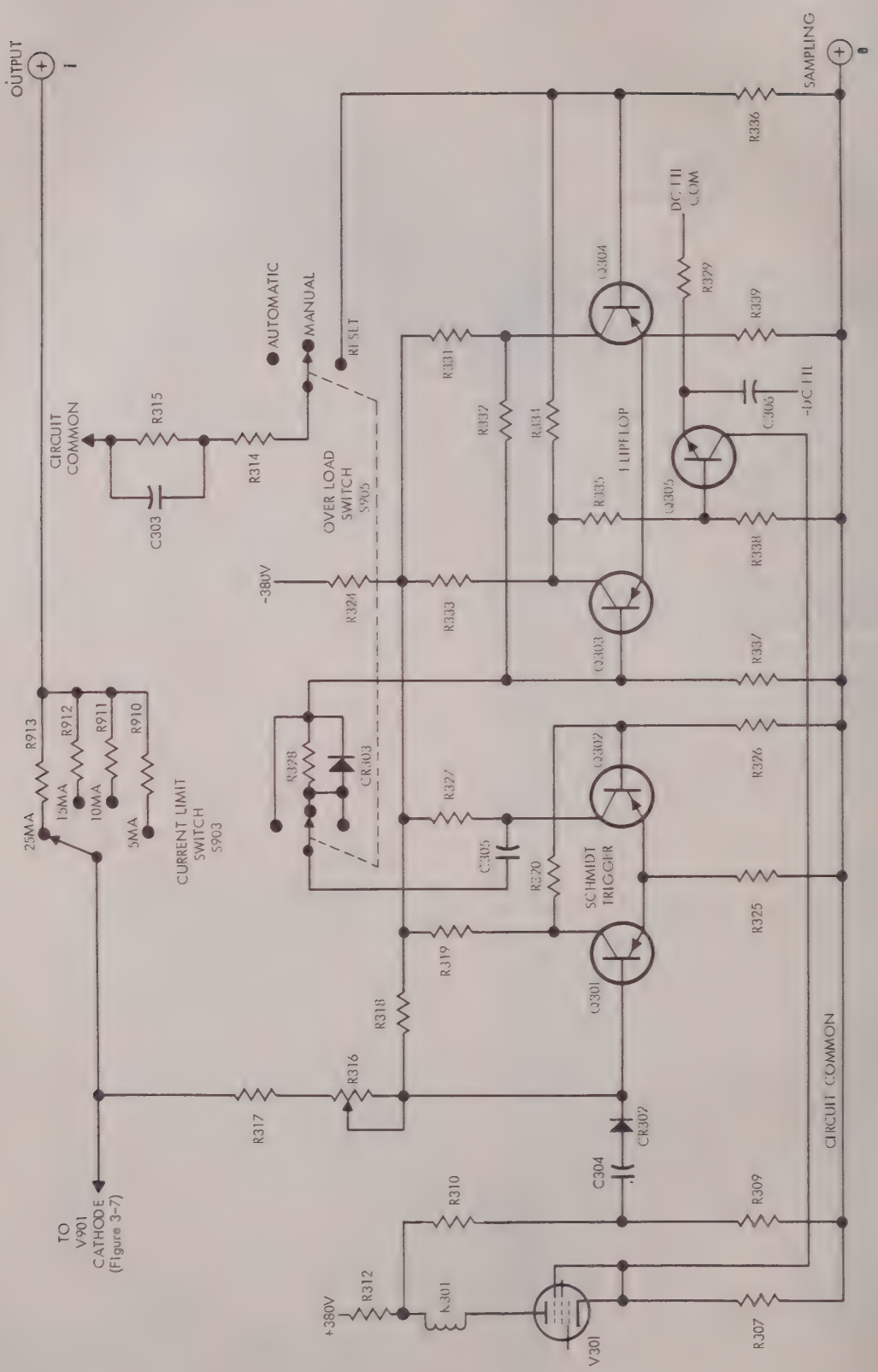


Figure 3-9. Over-Current Protective Circuits, Simplified Schematic Diagram

Section IV
MAINTENANCE

4-1 INTRODUCTION

This section contains information on the maintenance and repair of the Model 303 DC Voltage Standard. The maintenance data provided involves discussion and specific instructions relevant to the following:

a. Illustrations and text for identification of various modules and components of the instrument.

b. Recommendations for preventive maintenance, and instructions for cleaning, lubricating, and calibration.

c. Generalized instructions for corrective maintenance, trouble-shooting procedures and circuit analysis.

d. Maintenance support data including test points, typical waveforms found in normal operation, a list of replacement parts, and a complete set of schematic diagrams.

4-2 GENERAL MAINTENANCE INFORMATION

Before making any repairs or adjustments to the Model 303 take note of the following:

a. Transistor Circuits. Turn off instrument before attempting to remove transistors for replacement or check. Transistors are of the plug-in type.

b. Printed Circuit Boards. When servicing printed circuits do not push or pull wires in such a way as to raise the printed wiring from the board. When soldering leads, use 50 watt iron or smaller. Apply heat sparingly to the leads on the part to be replaced, not to the printed circuit board. Before installing new parts, clean holes to receive new part without forcing. Have new leads tinned and, if necessary, fluxed to receive solder quickly with a minimum of heat and without residue. Carefully insert the leads of the new part through the holes in the board, hold the part against the board and solder leads quickly to the printed circuit. When handling the printed circuit boards it is advisable to hold them by the edges in order not to touch the printed circuits.

4-3 HOUSING REMOVAL AND INSTALLATION

WARNING

Before removing housings and turning on instrument for the purpose of troubleshooting, B GUARD, C GUARD, and + SAMPLING terminals should be connected together and connected to conduit ground. This is an important safety precaution as high voltages exist within the instrument. When trouble-shooting with the power on, take care -- not chances.

The Model 303 chassis and B case may be removed from the housing by releasing the two captive screws on

the rear of the housing. Stand the instrument on the front handles and slide housing from chassis. Make provision for extra lead length of power cord when removing housing. If trouble is experienced when installing the housing, the power cord may be caught at the rear of the housing.

4-4 ASSEMBLY IDENTIFICATION

The internal views of the Model 303 DC Voltage Standard, Figures 4-1 and 4-2, identify the major components and subassemblies. Figure 4-3 shows the interior view locating the power terminal board, the AC power switch, the muffin fan assembly, the primary power fuse, and the output terminals.

Mechanically, the instrument consists of the chassis assemblies, and the front panel which is isolated from the rest of the chassis by fiber blocks. The main case and cross-members make up the skeletal frame of the assembly. The resistance decade assembly is isolated by the fiber blocks within the frame assembly. The component circuit boards are mounted on the main frame cross-members by nylon standoffs. The final assembly, the fan mounting plate, is mounted on the rear of the main frame and isolated by additional fiber blocks. With this effective isolation, voltage potentials may exist between the individual chassis or assemblies. For this reason extreme care should be used when servicing the instrument with the housing removed.

4-5 PREVENTIVE MAINTENANCE

Preventive maintenance or routine servicing recommendations for the Model 303 consist of cleaning the instrument and conducting a performance checkout.

4-6 CLEANING

Cleaning the Model 303 involves cleaning and recoating the air filter and removing accumulated dust and contaminants which may have collected on the interior surfaces of subassemblies and component boards.

4-7. FILTER. Air filter cleaning involves removing, washing and recoating of the shredded metal element. The filter is located on the rear housing of the unit and is fastened in a frame with four screws. The filter should be cleaned at approximately 60 day intervals depending upon the environmental conditions. Remove the four screws which secure the frame and separate filter and frame from the housing.

NOTE

Operation of the Model 303 is inadvisable with the filter removed or when the air intake is restricted by dirt or dust.

Filter cleaning is accomplished by circulating the element in warm soapy water. Household detergents are good for this purpose. Flush the filter element with clear water and continue rinsing until the runoff is clear. The filter element may be recoated with RP Super Handikoter No. 411, manufactured by Research Products Corporation, 1015 E. Washington Avenue, Madison 10, Wisconsin. The Handikoter contains one pint of compound, which is sufficient for several coatings. Additional compound is available from the same source and is packaged in one-gallon (No. 420) and five-gallon (No. 421) units. The one-gallon package is stocked by KIN TEL under Part No. 3310053.

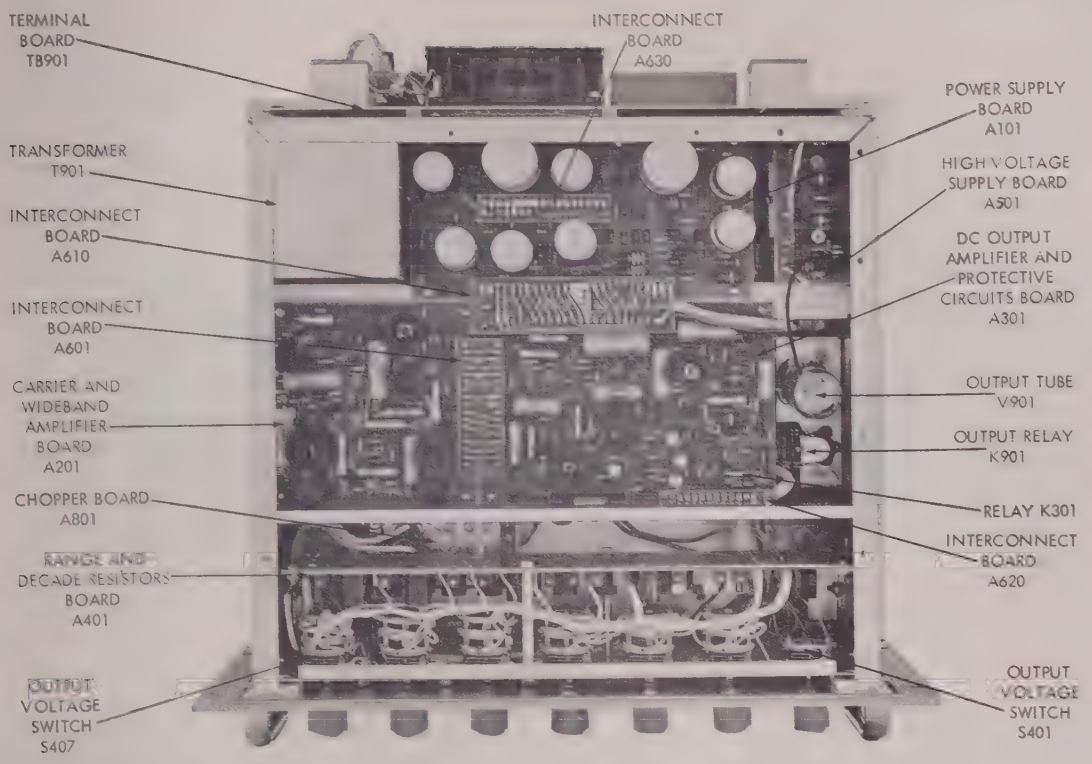


Figure 4-1. Major Components and Subassemblies, Top View

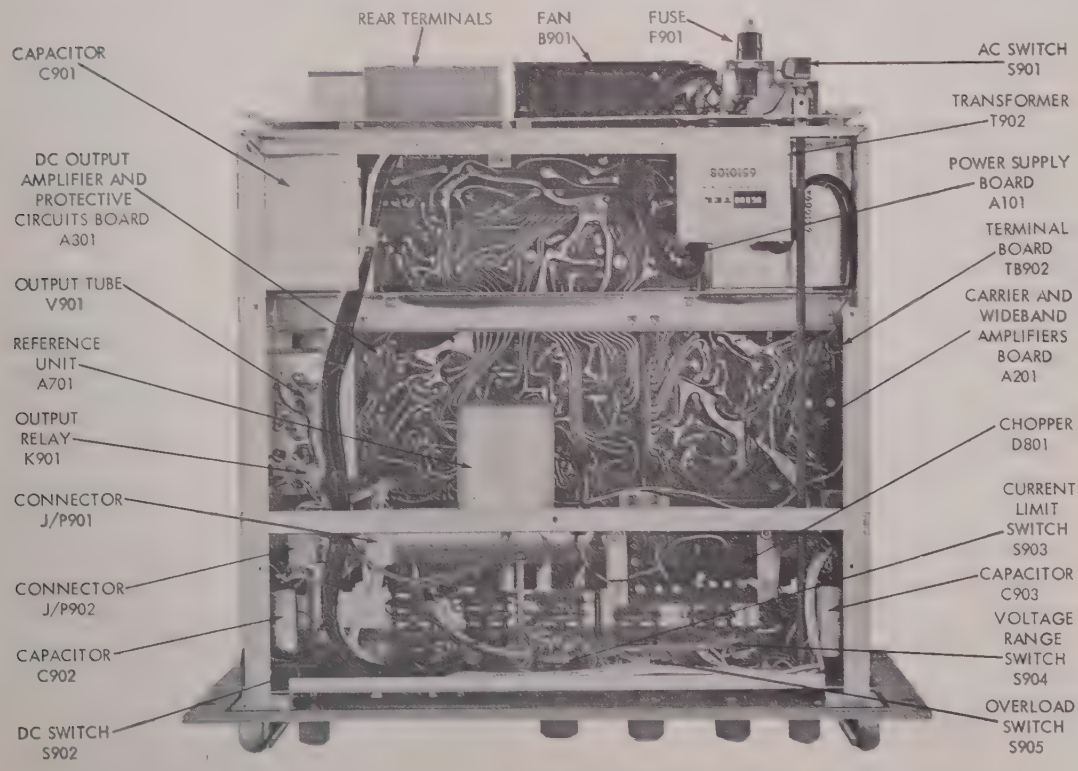


Figure 4-2. Major Components and Subassemblies, Bottom View

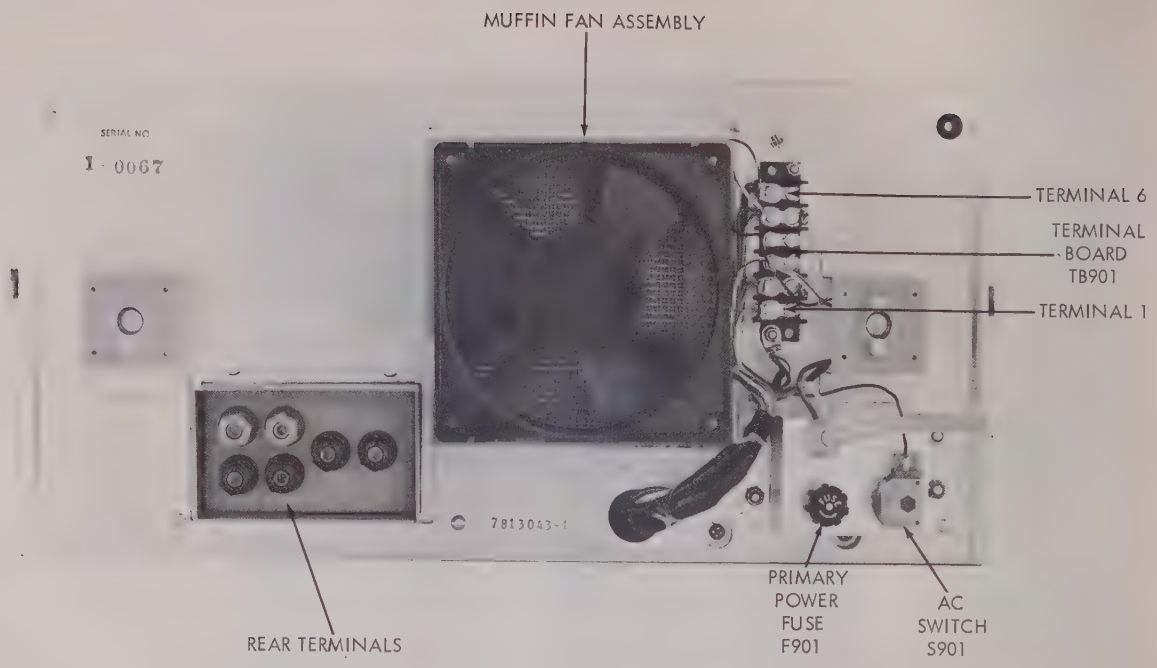


Figure 4-3. Major Components, Rear View

Before returning the instrument to its housing, clean the air filter screens attached to the inner shields by applying air pressure from inside the instrument.

4-8. INTERIOR. The interior should be cleaned as required. Relay and switch contacts are more sensitive to dirt and dust than any other area. A light brushing or low pressure air should be used in most applications.

CAUTION

When brushing or blowing dust from the interior take care to avoid damaging component boards. Excessive air pressure in critical areas may cause damage to components.

4-9 PERFORMANCE CHECKOUT

The intervals between routine preventive maintenance activities depend on the use of the instrument and the available facilities for bench checks. Where the DC Voltage Standard is in operational use daily, the necessity of a functional check on the maintenance bench is relieved. Where the use of the instrument is intermittent and it is idle for extended periods, check the instrument in accordance with paragraphs 2-8 and 2-9.

For an additional bench check, a null meter may be used to compare the output of the Model 303 with a stable reference -- standard cell of K3 Pot, etc. High voltage comparison may be accomplished with the use of a volt box in conjunction with the reference. Inter-terminal connections are shown in Figure 4-4. The low side of the probe (LO terminal of null indicator) is connected to the Model 303 + SAMPLING terminal, which may be connected to ground. Reference positive is then connected to the Model 303 + SAMPLING terminal, and reference negative to the high side of the nulling

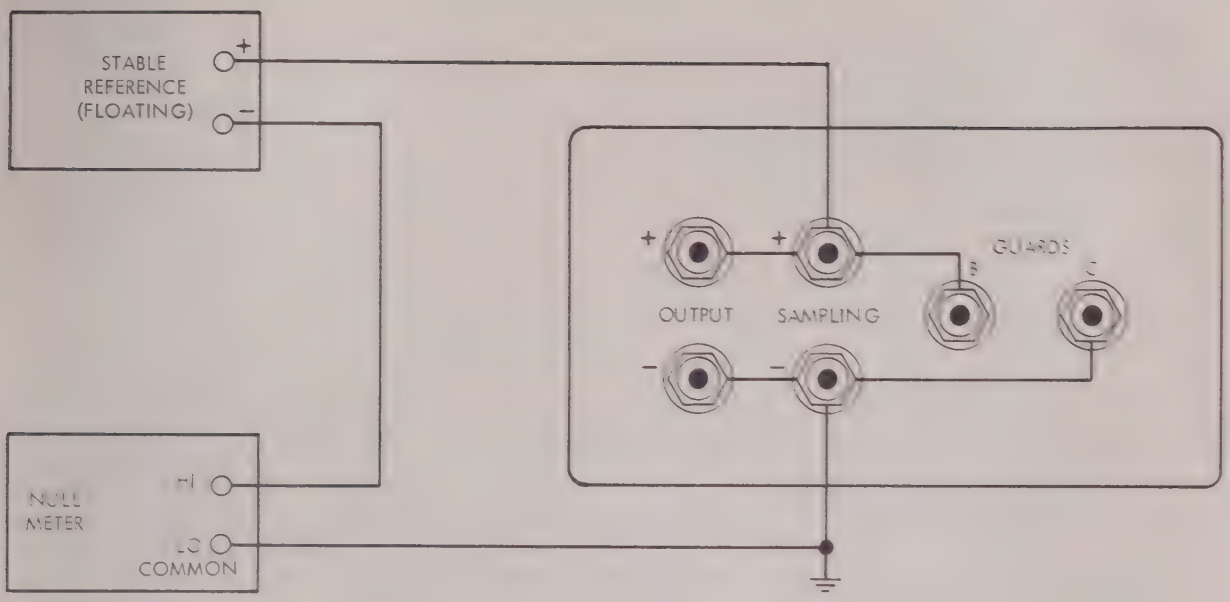


Figure 4-4. High Voltage Comparison Setup

device. Note that when the Model 303 is not equipped with B GUARD terminal, it is necessary only to omit the connection to this terminal.

4-10 CALIBRATION

Calibration consists of first adjusting for zero volt output, then linearization, range adjustments, and finally scale adjustment. Only one known standard voltage is needed to calibrate the Model 303 and is used for the final adjustment. Linearization and range adjustments are performed using a variable supply of stable voltage. The recommended method is to use another Model 303 or its equivalent. An alternative method is to use a volt box and a K3 potentiometer. The galvanometer to be used should be an electronic galvanometer such as the KIN TEL Model 204A or its equivalent. The calibration procedure to be followed is outlined in paragraphs a through e below.

a. Preliminary Procedure

1. Apply power to the Model 303 and the test equipment.

2. Allow at least one hour for the instrument to stabilize.

3. Set the Model 303 CURRENT LIMIT switch to 5.

4. Set the Model 303 OVER LOAD switch to AUTO.

5. Set the Model 303 output voltage dials to indicate zero volts.

6. Slide the Model 303 out of its case until the adjustment screws of the variable resistors are accessible.

b. Zero Adjustment

NOTE

Steps b. 2 through b. 5 are not applicable to Model 303 instruments bearing serial numbers 1-0001 through 1-0055.

1. Connect the Model 303 to the galvanometer as shown in Figure 4-5. Short instrument at output terminals. Zero the galvanometer. Remove the short.

2. Set the VOLTAGE RANGE switch to 10.

3. Adjust R814 to obtain a zero volt indication on the galvanometer, using the most sensitive scale (10 μv f.s. on Model 204A).

4. Set the VOLTAGE RANGE switch to 100.

5. Adjust R811 to obtain a zero volt indication on the galvanometer.

6. Set the VOLTAGE RANGE switch to 1000.

7. Adjust R808 to obtain a zero volt indication on the galvanometer.

c. Linearity Adjustment

1. Connect the Model 303 to the test equipment as shown in Figure 4-6 or 4-7.

2. Set the output controls to 00.X0000 and set the bucking voltage to 1 volt. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 01.00000 and adjust R423 to obtain the same null within the limits of ±10 microvolts.

3. Set the controls to 01.X0000 and set the bucking voltage to 2 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 02.00000 and adjust R425 to obtain the same null within the limits of ±10 microvolts.

4. Set the controls to 03.X0000 and set the bucking voltage to 4 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 04.00000 and adjust R426 to obtain the same null within the limits of ±10 microvolts.

5. Set the controls to 07.X0000 and set the bucking voltage to 8 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 08.00000 and adjust R429 to obtain the same null within the limits of ±10 microvolts.

6. Set the controls to 0.X00000 and set the bucking voltage to 1 volt. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 1.000000 and adjust R430 to obtain the same null within the limits of ±10 microvolts.

7. Set the controls to 1.X00000 and set the bucking voltage to 2 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 2.000000 and adjust R444 to obtain the same null within the limits of ±10 microvolts.

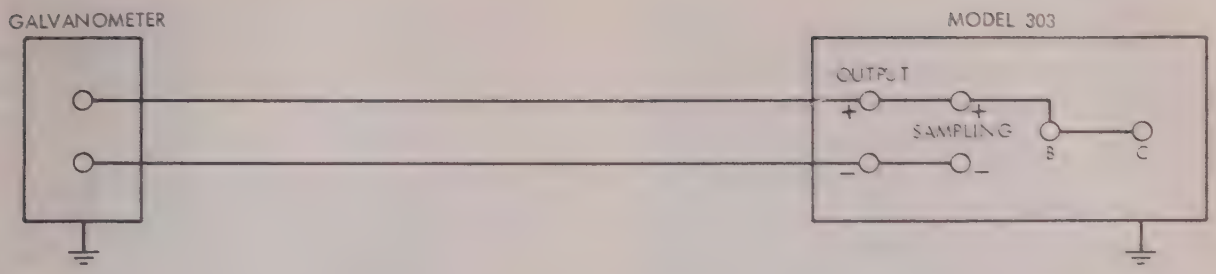


Figure 4-5. Calibration Connections, Zero Volt Output Adjustment

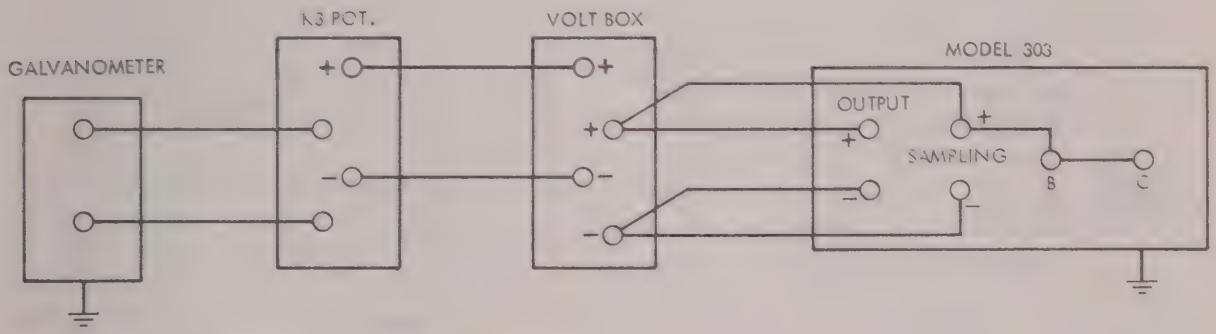


Figure 4-6. Calibration Connections, Linearization

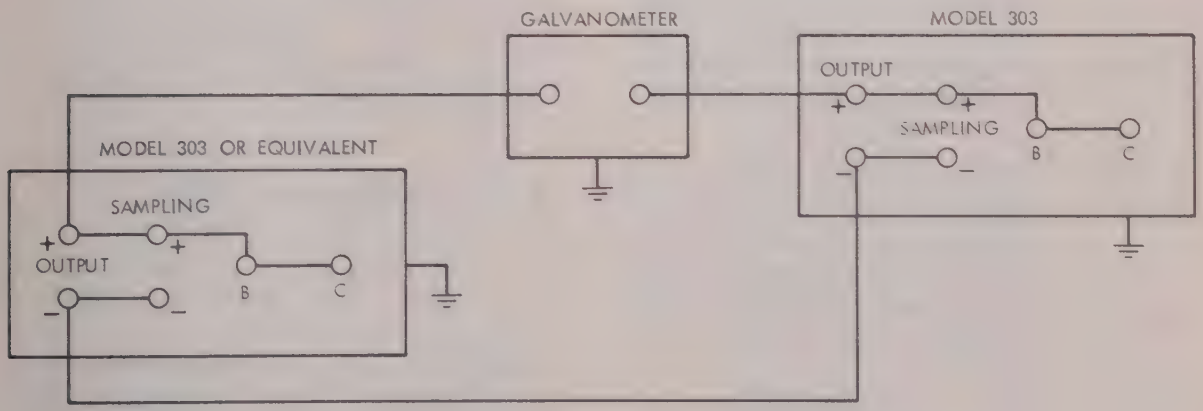


Figure 4-7. Calibration Connections, Linearization

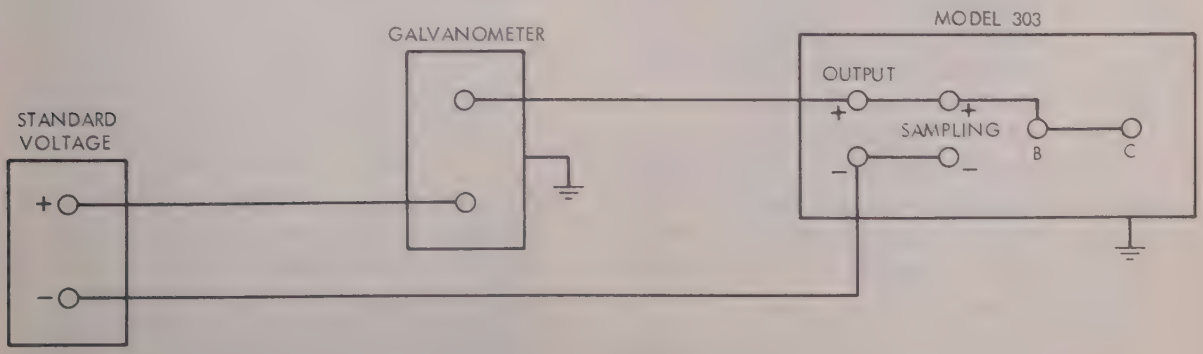


Figure 4-8. Calibration Connections, Scale Adjustment

8. Set the controls to 3.X00000 and set the bucking voltage to 4 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 4.000000 and adjust R443 to obtain the same null within the limits of ±10 microvolts.

9. Set the controls to 7.X00000 and set the bucking voltage to 8 volts. Adjust the bucking voltage to obtain a null on the galvanometer. Set the controls to 8.000000 and adjust R442 to obtain the same null within the limits of ±10 microvolts.

d. Range Adjustment

1. The same calibration setup is used to linearize the ranges as was used for the linearization of the resistance decade.

2. Set the output controls to 10.000000 (note, extreme left dial at 10) and set the bucking voltage to 10 volts. Adjust the bucking voltage to obtain a null on the galvanometer.

3. Set the controls to 0X.00000 and adjust R402 to obtain the same null as in step d.2 within the limits of ±100 microvolts.

4. Set the controls to 00X.0000 and adjust R401 to obtain the same null as in step d.2 within the limits of ±100 microvolts.

5. Set the controls to 10.000000 (same setting as in d.2) and adjust R403 to obtain the same null as in step d.2 within the limits of ±100 microvolts.

6. Repeat steps 3, 4, and 5 until no further adjustment is needed.

e. Accuracy or Scale Adjustment

1. Set the output controls to indicate the value of a local standard voltage.

2. Connect the Model 303 to the galvanometer and the standard voltage as shown in Figure 4-8. The galvanometer sensitivity should be such as to permit adjustment within .001%.

3. Adjust R404 to obtain a null on the galvanometer.

4-11 TROUBLESHOOTING

Before attempting to troubleshoot this instrument it is advisable to become familiar with its theory of operation. Knowing how the instrument functions, the general area within which a fault exists sometimes can be determined simply by operating the controls and noting the results. Try this method and also try to locate the fault by visual inspection and smell. Check for overheated components, discolored resistors, broken wires, and cold electron tubes. If these methods fail to locate or localize the trouble a systematic check will have to be made. This is done by first localizing the fault to a particular circuit board or area and then locating the defective component.

4-12. TROUBLE LOCALIZATION. Most troubles which could arise in the Model 303 would trigger the protective circuit. A prime requisite for the technician troubleshooting this circuit is a thorough knowledge of the protective circuit operation described in paragraph 3-10 of this manual. Familiarity with the circuits and reference to Figure 4-9 and 4-10 will facilitate locating faults since the protective circuit must be operative before the relays will function. Voltage measurement in the operational circuits are not valid unless relays K301 and K901 are energized. The voltages given in Figure 4-10 were measured using a meter having a 100 M-ohm input, and the locations of the measurement points are shown in Figure 4-9.

If relay K301 de-energizes causing relay K901 to de-energize, the OVER LOAD indicator lamp on the front panel lights. Relay K901 de-energiving, opens the output voltage circuit to the negative terminal of the DC Voltage Standard. If the OVER LOAD indicator lights, one of the following protective circuit conditions may exist.

a. V301 is cut off by a signal at the control grid. This condition could be caused by an error signal (indicating an over-voltage condition) from the carrier amplifier exceeding the 2.7 volt back-bias on diode CR301 causing the diode to conduct, biasing V301 to cut-off, and de-energizing K301.

b. V301 is cut off by a high voltage on the cathode. This condition, in addition to above, could be caused by an error signal (indicating an over-current condition) from the cathode circuit of the output tube V901. Under normal conditions, the current-limit resistor in the cathode circuit is selected by the CURRENT LIMIT switch to provide less than 3 volts to the protective circuit. If this limit is exceeded, the protective circuit is triggered, lowering the collector current of Q305 and causing V301 to cut off.

c. There is an open filament in V201 or V203 (or the associated power supply is faulty) causing the collector current of Q305 again to drop, biasing V301 to cut-off.

To determine whether one of these three protective circuit conditions exists, perform the following procedures in paragraphs a, b, and c.

a. Over-current Condition

1. Set the DC switch to OFF. Check the output terminal connections. (Refer to Section II of this n anual). Remove the load on the instrument. Set the OVER LOAD switch to MAN and set the DC switch back to the ON position.

2. Set OVER LOAD switch to RESET. If the OVER LOAD lamp extinguishes and stays out, the fault has then been isolated to the load. Recalculate the load current required and set the CURRENT LIMIT switch accordingly. Set the DC switch to OFF and reconnect the load. Set the DC switch to ON, reset the OVER LOAD switch, and the instrument should be ready for operational use again.

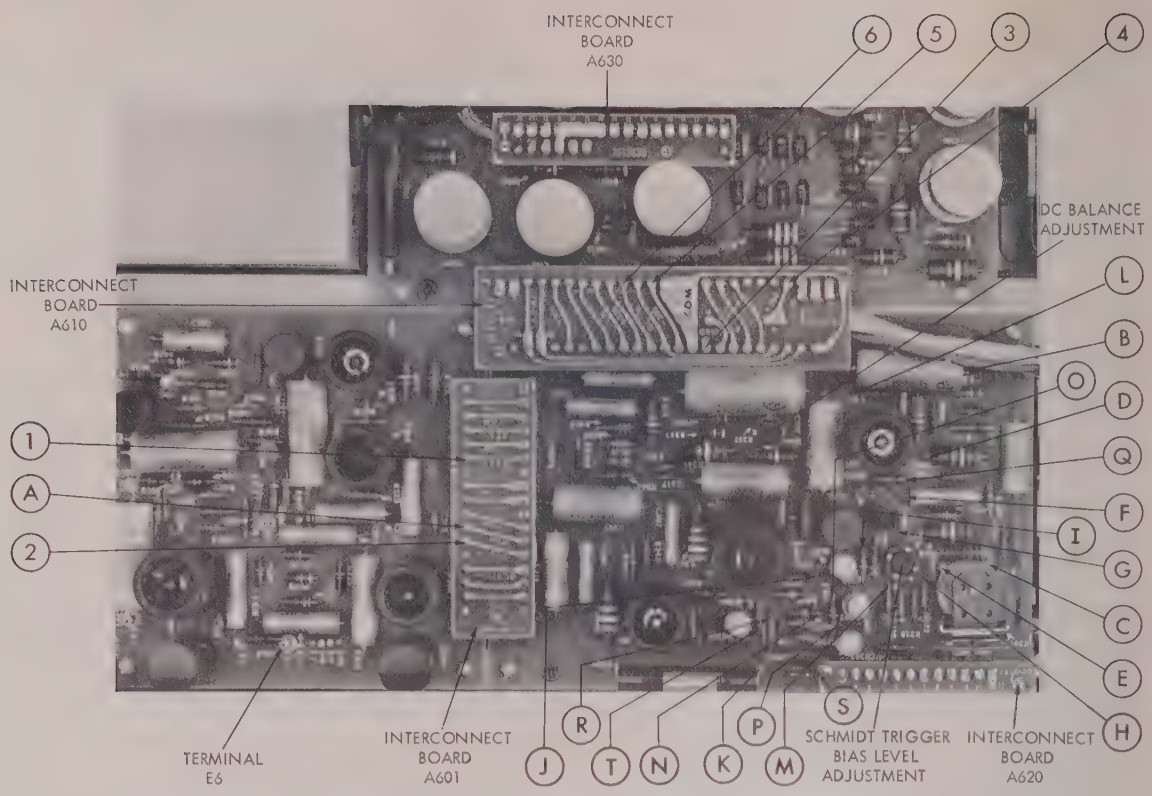


Figure 4-9. Check Point Locations

b. Filament or Power Supply Fault

1. Set the AC switch to OFF and remove power plug from convenience outlet. Remove the housing in accordance with paragraph 4-3. Remove top cover (B chassis cover) and remove tubes V201 and V203. Check the tubes for rated specifications ensuring that the filament circuits are not open. Install checked or replacement tubes into circuit board.

2. Connect the instrument to the convenience outlet and apply power by setting the AC switch to ON.

WARNING

Use extreme care in performing the following check as voltages of sufficiently high potential to cause serious injury are present.

3. Measure the voltage at the + and - points marked DC FIL on interconnect board A610 located between the power supply and the DC amplifier circuit boards. Voltage indication at both polarities should be approximately 12 volts DC.

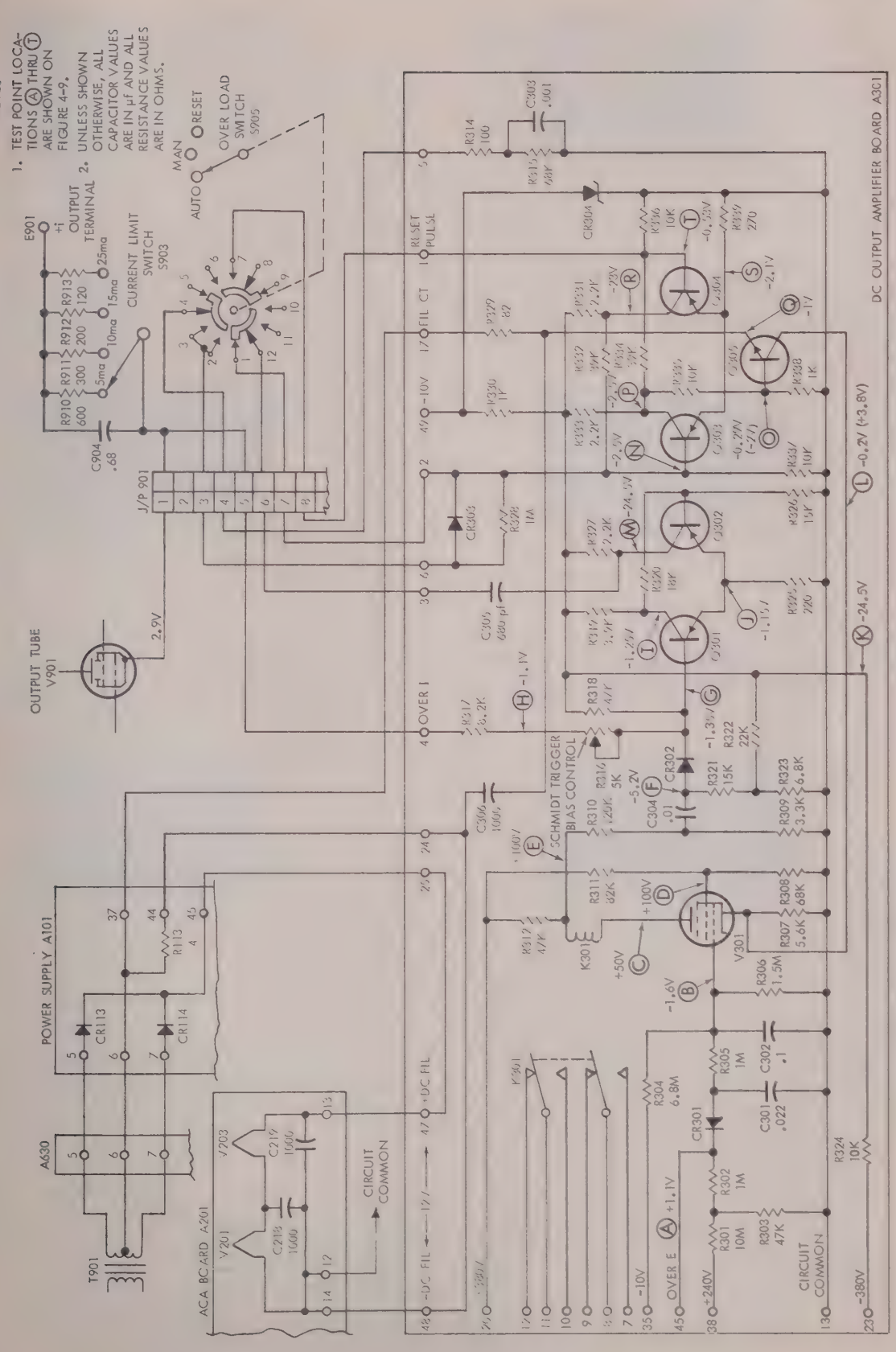


Figure 4-10. Over-Voltage and Over-Current Protective Circuits

4. Set the OVER LOAD switch to RESET. If the OVER LOAD lamp extinguishes and stays out, the fault has been remedied by the tube replacement and/or power supply check.

c. Over-voltage Condition

1. Momentarily short terminal E6 on the carrier amplifier circuit board to circuit common.

WARNING

Never short terminal E6 for more than one second.

Shorting E6 should remove the over-voltage condition to V301. If K301 remains de-energized, check for trouble in the circuits of V201B and V203.

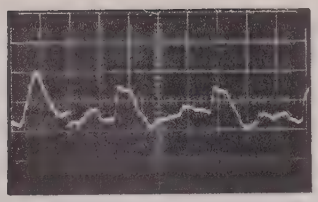
2. Measure the voltage on interconnect board A601 at the OVER E point; voltage should be +1.1 volts (present from the back-biased condition of CR301). The trouble is now isolated to the carrier amplifier circuits. If K301 remains energized (by resetting of OVER LOAD switch) with terminal E6 shorted, an excessive difference signal, appearing at the summing junction, has developed between the reference and the output voltage. With terminal E6 shorted, no signal is applied to CR301; therefore, grid bias should remain normal or below the cut-off level (approximately -1.6 volts). If an excessive difference or correcting signal is suspected, measure the AC voltage on interconnect board A601 at point marked DCA 2. The normal correcting voltage at this point is less than 10 volts peak-to-peak. If this voltage is noticeably higher, the DC output amplifier is not responding to the applied signal.

Any fault not located by association with the protective circuits can be localized with the aid of the overall schematic diagrams, Figures 4-23 and 4-24. Make a systematic check of the voltages shown in these figures and the individual circuit board schematic diagrams, Figures 4-18 through 4-22, and trace signals to localize the fault to a particular area. Most checks can be made at the interconnect boards shown in Figure 4-9. The waveforms shown in Figure 4-11 appear at the points indicated by the figures (1) through (6) in Figure 4-9 and show normal operating conditions. These points also are indicated by the same numbers on the schematic diagrams.

4-13. TROUBLE ISOLATION. After a fault has been localized to a particular area, such as a circuit board, locate the faulty component by employing the usual troubleshooting techniques of tracing signals and measuring voltages and resistance; no special techniques are required. Systematically check the circuits with the aid of the appropriate schematic diagram. Circuit details of the resistance decade circuit board and output voltage switches, and other circuit boards, are not shown in the overall schematic diagram but for convenience are shown separately. The locations of components are shown in Figures 4-12 through 4-17.

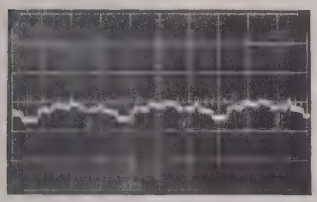
①
DCA1

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 50 MILLIVOLTS/CM



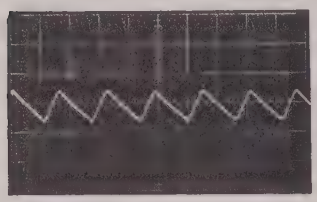
②
DCA2

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 5 VOLTS/CM



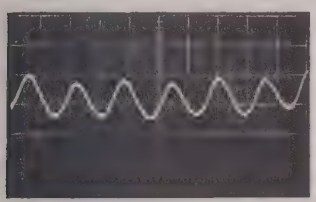
③
V901 GRID

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 50 MILLIVOLTS/CM



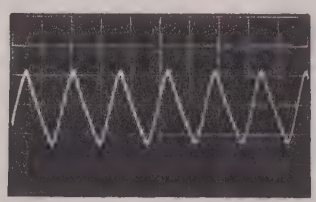
④
+380V

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 5 VOLTS/CM



⑤
-380V

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 100 MILLIVOLTS/CM



⑥
+DC FIL

SWEEP: 5 MILLISECONDS/CM
SENSITIVITY: 500 MILLIVOLTS/CM

NOTE

FIGURES①THROUGH⑥INDICATE WAVE-FORM CHECK POINTS ON FIGURE 4-9 AND SCHEMATIC DIAGRAMS.

Figure 4-11. Normal Waveforms

When the value of a resistor is suspected of being low, check the schematic diagram for other resistance connected in parallel with it before replacing. If in doubt, remove the resistor from the circuit and remeasure its value. It is recommended that no attempt be made to troubleshoot the reference unit. If it is found to give trouble it should be replaced as special treatment is necessary to correct a faulty reference unit.

4-14. SCHMIDT TRIGGER BIAS LEVEL ADJUSTMENT. Whenever the protective circuit has been repaired the level of bias for the Schmidt Trigger circuit should be adjusted, as follows:

a. Set the OVER LOAD switch to AUTO.

b. Set the CURRENT LIMIT switch to 25.

c. Connect a 25 MA load to the instrument.

d. Adjust R316 (see Figure 4-9 for location) until the OVER LOAD indicator just starts to flash on and off.

4-15. DC BALANCE ADJUSTMENT. Whenever the carrier amplifier circuit has been repaired the DC balance should be adjusted as follows:

a. Connect an oscilloscope between test point DCA 2 on interconnect board A601 (see Figure 4-9 for location) and the + SAMPLING terminal (common).

b. Set the oscilloscope to 2 volts per centimeter sensitivity.

c. Adjust R352 to obtain a null on the oscilloscope. The signal should have a peak-to-peak voltage of not more than 10 volts (see Figure 4-11 for waveform).

4-16 MECHANICAL ASSEMBLIES

The mechanical assemblies in the instrument consist of the fan assembly; output voltage, range, current limit, and overload switches, relays and chopper; and the individual chassis frames. These units, except the fan motor, are assembled and lubricated as applicable for the lifetime of the instrument, therefore under normal operating conditions little mechanical maintenance is required.

4-17. SWITCHES. The precision switches have a contact life of more than 50,000 operations with negligible change in rotor contact resistance. Rotor contacts are double-wiping and self-cleaning and as such require little or no maintenance.

4-18. CHOPPER. One of the two continuously moving parts of the instrument is the chopper. Output noise and stability characteristics are readily degraded by a malfunctioning chopper. The most valid test of chopper performance is the substitution of a chopper with one known to be good. More detailed information on the nature and function of choppers is presented in KIN TEL Service Notes, Code No. 13-57A, Chopper Checkout Procedures for KIN TEL Equipment.

4-19. RELAYS. The relays are activated at random intervals determined by specific operating requirements. Maintenance consists of checking contact points to insure good contact. Maintenance personnel not especially trained or equipped to service relays of this type should substitute a good replacement spare.

4-20. FAN MOTOR. The fan motor is a sealed unit requiring little maintenance and will give reliable performance from two to five years under

usual conditions without the necessity of oiling. The life of the fan motor may be extended by periodic oilings. The oiling procedure requires the use of an oil injector which may be obtained from ROTRON Manufacturing Company, Inc., Hasbrouck Lane, Woodstock, New York. The oiling procedure is as follows:

a. Remove the cap from the end of the oil injector.

b. Place needle of oil injector at the center of circle marked on the gold label.

c. Position the needle at an angle of approximately 45° to the surface of the label and tangent to the perimeter of the circle.

d. Pierce the label and the concealed self-sealing rubber cap located under the label.

e. Insert the needle approximately 1/4 inch.

f. Depress the plunger of the oil injector slowly to allow approximately 1/16 inch of oil to escape.

It is better to give a little more oil than not enough, however, do not overflow the well.

4-21 REPLACEMENT PARTS AND RECOMMENDED SPARES

A list of replacement parts, arranged alphabetically and numerically according to circuit symbol, is contained in Table 4-1, and lists of recommended spares which are available as kits are contained in Table 4-2.

NOTE

If the value of a component to be replaced is different from that listed in Table 4-1, replacement should be made using the component listed.

Figure 4-12. Power Supply Board, Component Locations

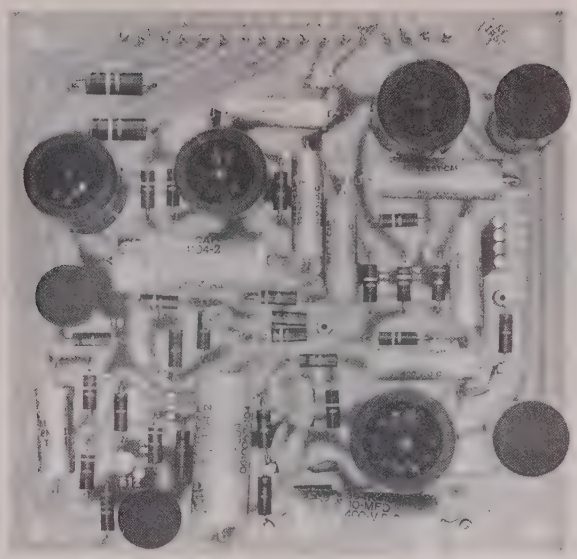


Figure 4-13. Carrier and Wideband Amplifiers Board, Component Locations

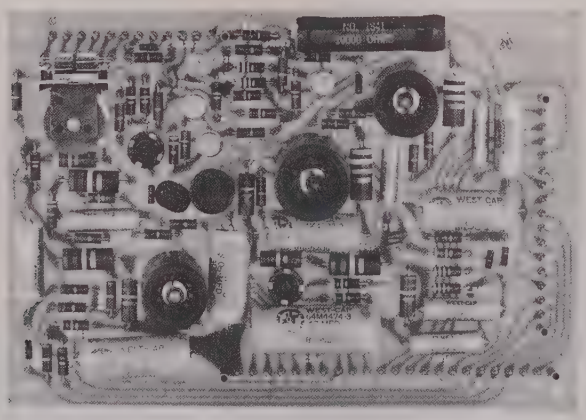


Figure 4-14. DC Output Amplifier and Protective Circuits Board, Component Locations

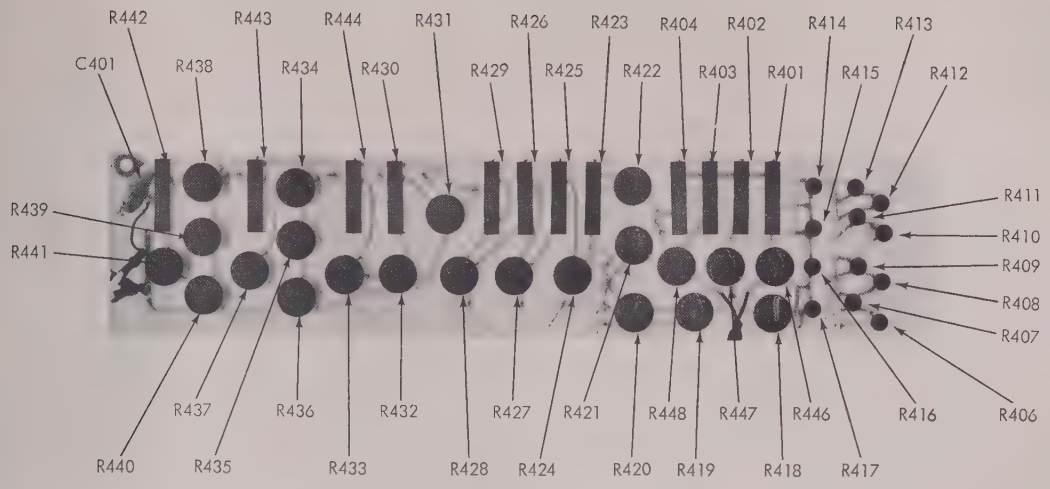


Figure 4-15. Resistance Decade Board, Component Locations

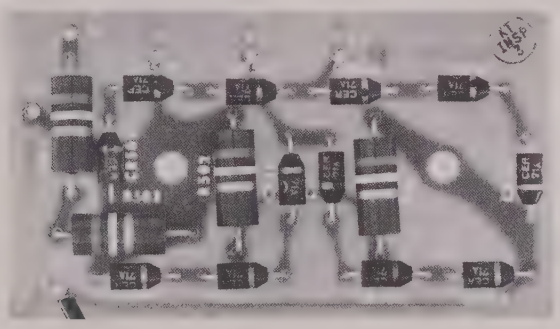


Figure 4-16. High Voltage Power Supply, Component Locations

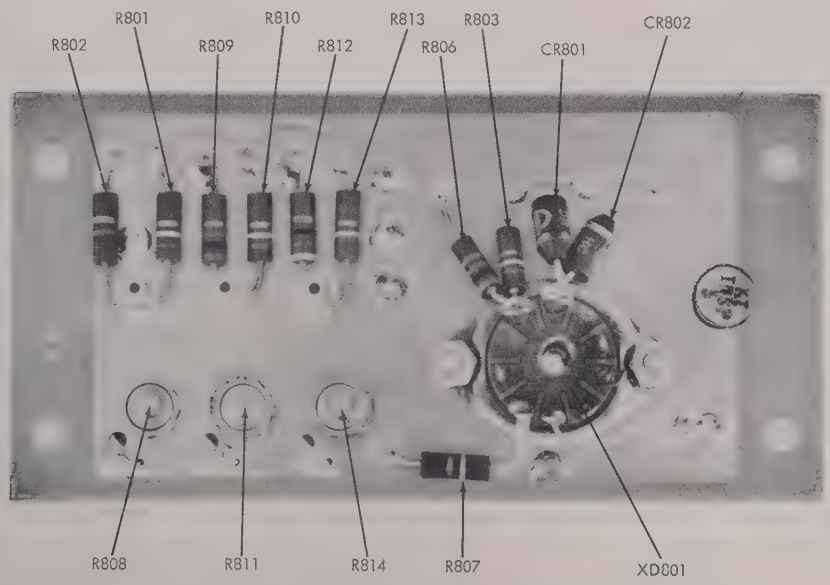


Figure 4-17. Chopper Board, Component Locations

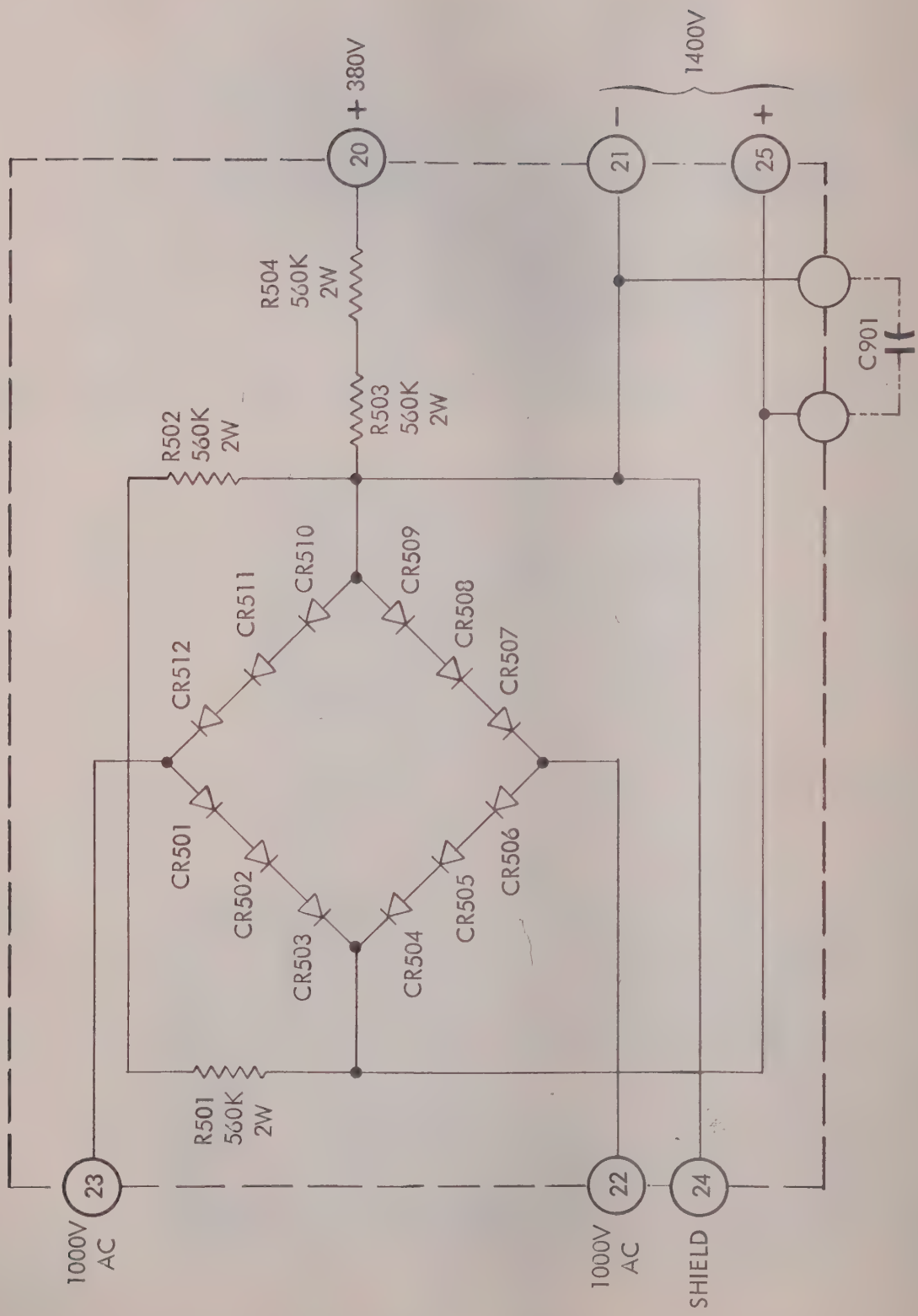


Figure 4-18. High Voltage Power Supply Board, Schematic Diagram (Drawing No. C78135003)

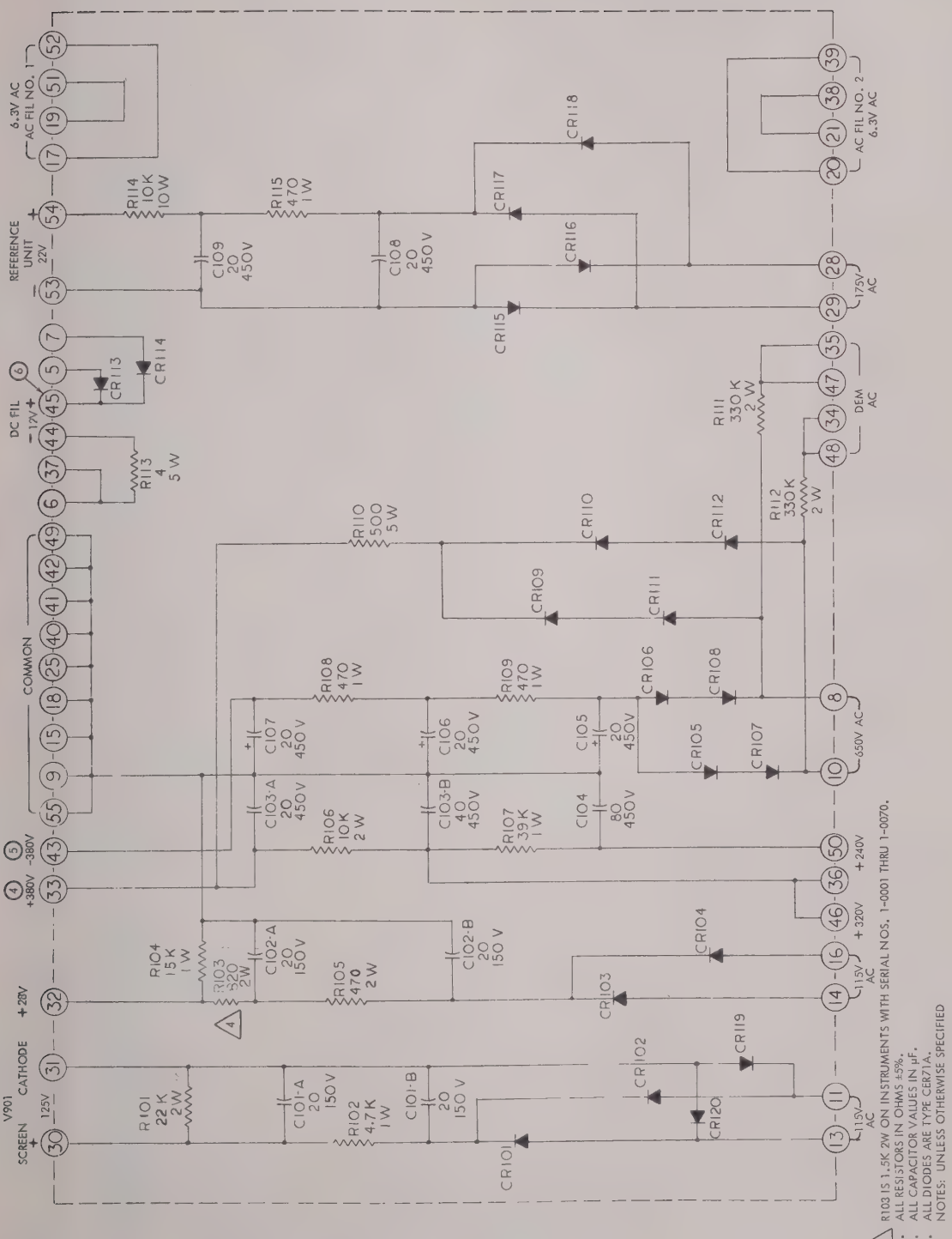


Figure 4-19. Power Supply Circuit Board, Schematic Diagram (Drawing No. D7813100A)

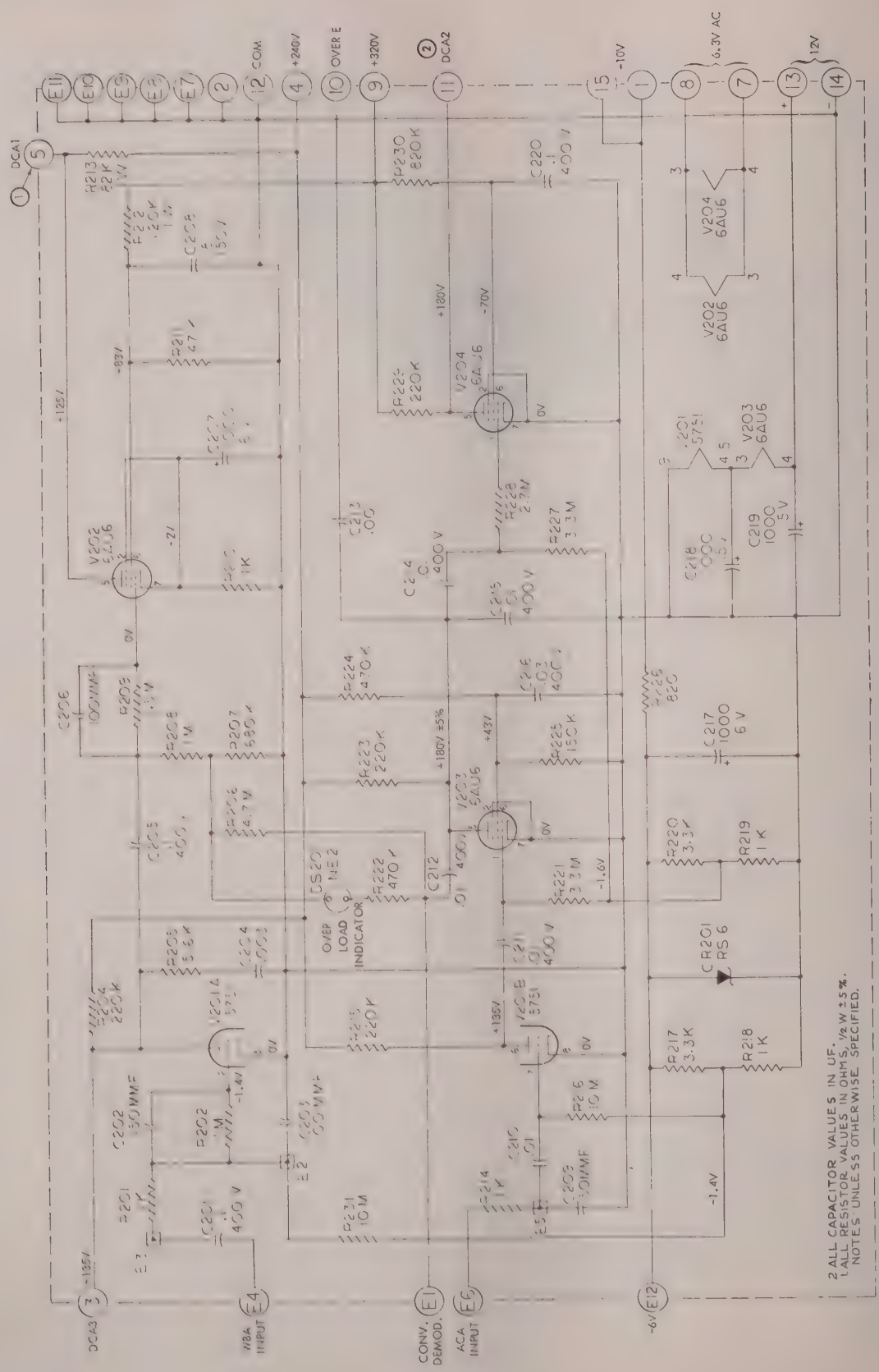


Figure 4-20. Carrier and Wideband Amplifiers Circuit Board, Schematic Diagram (Drawing No. D7813200A)

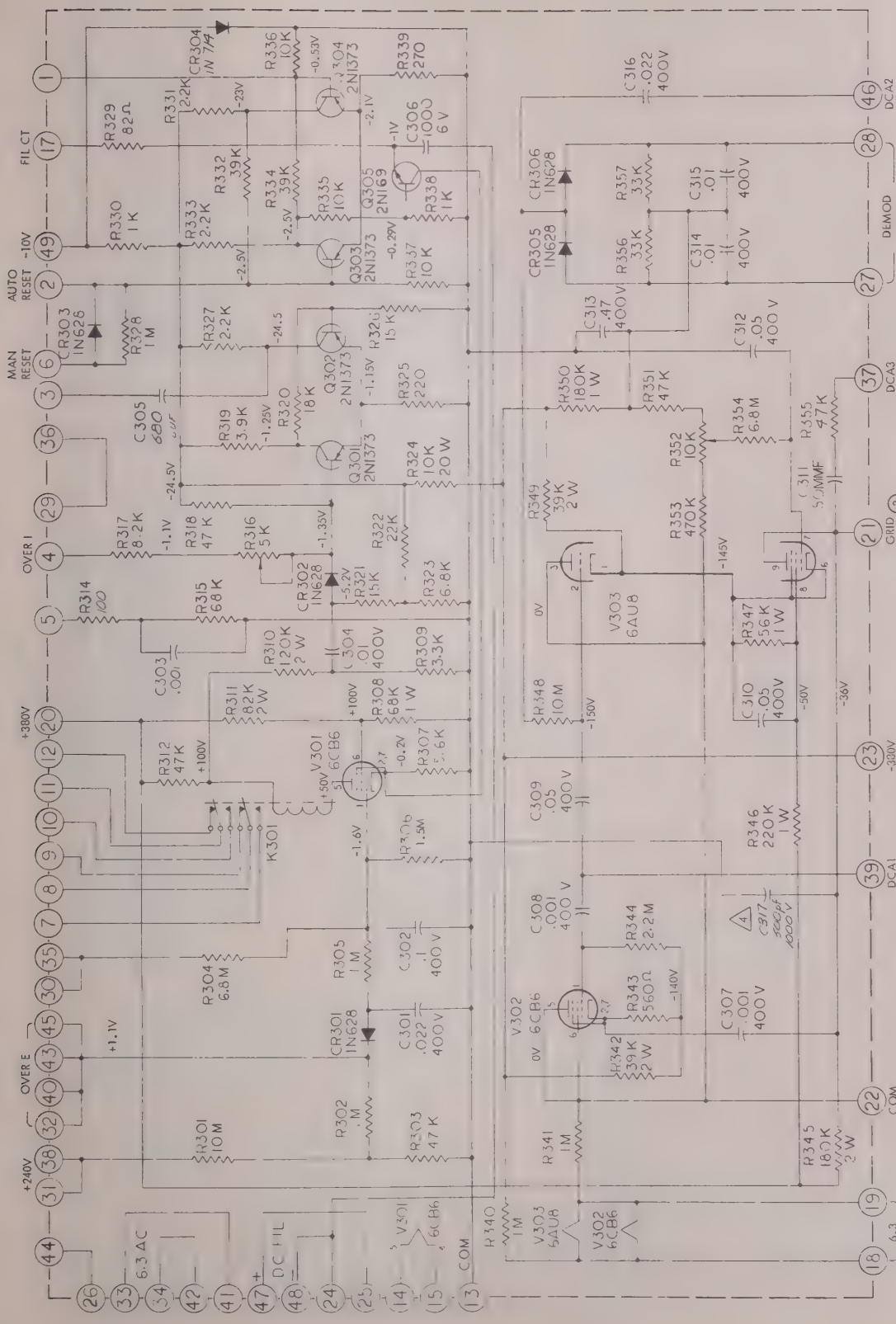


Figure 4-21. DC Output Amplifier Circuit Board, Schematic Diagram (Drawing No. 7813300E)

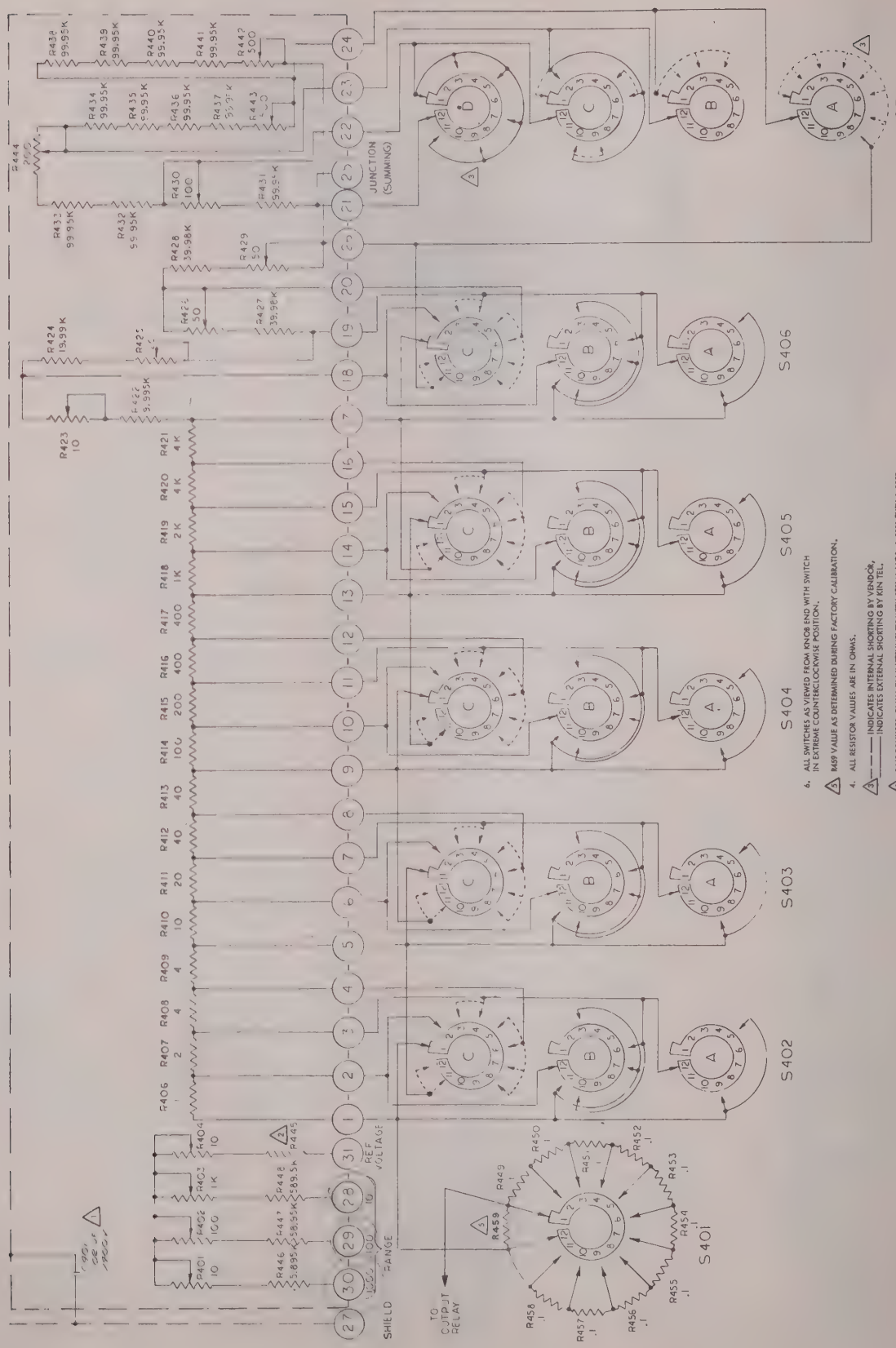
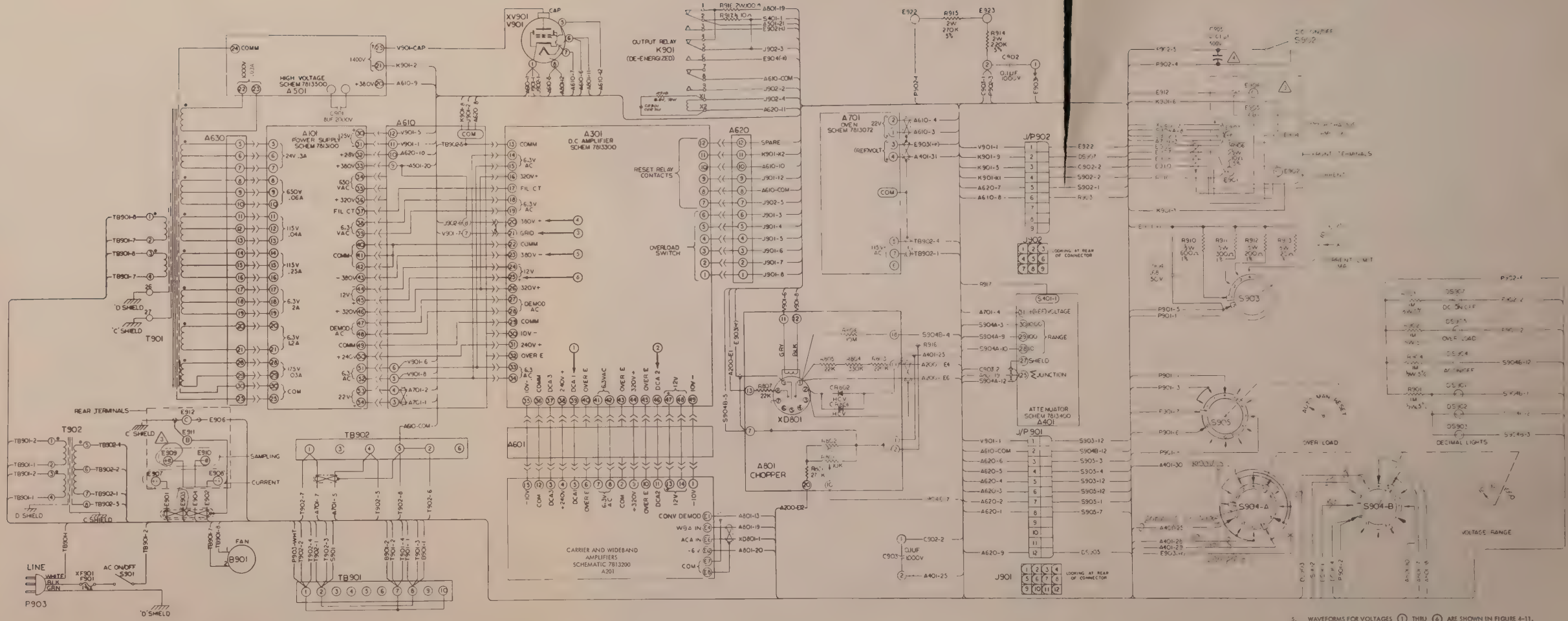

S401
S402
S403
S404
S405
S406
S407
JUNCTION (SUMMING)
REF VOLTAGE
SHIELD
TO OUTPUT RELAY
6. ALL SWITCHES AS VIEWED FROM KNOB END WITH SWITCH IN EXTREME COUNTERCLOCKWISE POSITION.
△5 R459 VALUE AS DETERMINED DURING FACTORY CALIBRATION.
4. ALL RESISTOR VALUES ARE IN OHMS.
△3 —— INDICATES INTERNAL SHORTING BY VENDOR, —— INDICATES EXTERNAL SHORTING BY KIN TEL.
△2 R445 EQUIPPED ONLY ON INSTRUMENTS WITH SERIAL NOS. 1-0001 THRU 1-0055.
△1 C401 NOT EQUIPPED ON INSTRUMENTS WITH SERIAL NOS. 1-0001 THRU 1-0055.
NOTES: UNLESS OTHERWISE SPECIFIED.

Figure 4-22. Resistance Decade Circuit Board, Schematic Diagram (Drawing No. D7813400C)



5. WAVEFORMS FOR VOLTAGES (1) THRU (6) ARE SHOWN IN FIGURE 4-11.

4 NOT ALL INSTRUMENTS ARE EQUIPPED WITH C905.

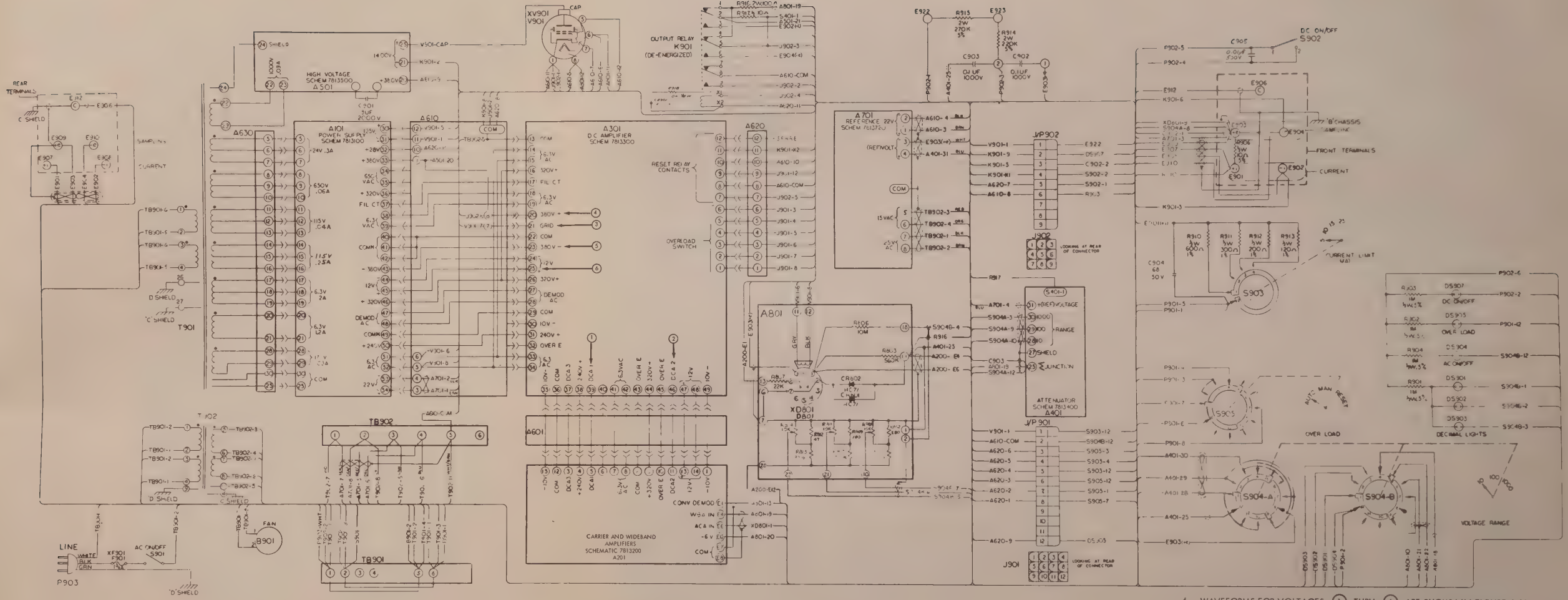
3 FRONT AND REAR TERMINAL CONNECTIONS SHOWN ARE APPLICABLE TO INSTRUMENTS EQUIPPED WITH 8 GUARD TERMINALS (E905 & E911).

2. FOR INSTRUMENTS WITH SERIAL NOS. 1-0056 AND ON, SEE DRAWING 7813901.

1. THIS SCHEMATIC EFFECTIVE FOR INSTRUMENTS WITH SERIAL NOS. 1-0001 THRU 1-0055.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 4-23. Model 303, Overall Schematic Diagram (Drawing No. J7813900D)



4. WAVEFORMS FOR VOLTAGES (1) THRU (6) ARE SHOWN IN FIGURE 4-11.
3. FRONT AND REAR TERMINAL CONNECTIONS SHOWN ARE APPLICABLE TO INSTRUMENTS NOT EQUIPPED WITH B GUARD TERMINALS.
2. FOR INSTRUMENTS WITH SERIAL NOS. 1-0001 THRU 1-0055 SEE DRAWING 7813900.
1. THIS SCHEMATIC EFFECTIVE FOR INSTRUMENTS WITH SERIAL NOS. 1-0056 AND ON.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 4-24. Model 303, Overall Schematic Diagram (Drawing No. 7813901H)

Table 4-1. List of Replacement Parts

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
A101	ASSEMBLY, PRINTED CIRCUIT, Power Supply	7813101-001
A201	ASSEMBLY, PRINTED, CIRCUIT, Carrier and Wideband Amplifiers	7813201-001
A301	ASSEMBLY, PRINTED CIRCUIT, DC Output Amplifier	7813301-001
A401	ASSEMBLY, PRINTED CIRCUIT, Range and Decade Resistors	7813401-001
A501	ASSEMBLY, PRINTED CIRCUIT, High Voltage	7813501-001
A601	ASSEMBLY, PRINTED CIRCUIT, Amplifier Board Connector	7813601-001
A610	ASSEMBLY, PRINTED CIRCUIT, Power Supply Board Connector	7813610-001
A620	ASSEMBLY, PRINTED CIRCUIT, Reset Board Connector	7813620-001
A630	ASSEMBLY, PRINTED CIRCUIT, Power Transformer Board Connector	7813630-001
A701	REFERENCE UNIT	7813091-001
A801	ASSEMBLY, PRINTED CIRCUIT, Chopper	7813801-001
B901	FAN, ELECTRICAL, 100 cfm, 115-120 VAC, 60 CPS	3110023-002
C101	CAPACITOR, FIXED, ELECTROLYTIC, 20/20 μf, 150 VDC	0510059
C102	CAPACITOR, FIXED, ELECTROLYTIC, 20/20 μf, 150 VDC	0510059
C103	CAPACITOR, FIXED, ELECTROLYTIC, 20/40 μf, 450 VDC	0510121-006

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
C104	CAPACITOR, FIXED, ELECTROLYTIC, 80 μf, 450 VDC	0510121-005
C105	CAPACITOR, FIXED, ELECTROLYTIC, 20 μf, 450 VDC	0510122-002
C106	CAPACITOR, FIXED, ELECTROLYTIC, 20 μf, 450 VDC	0510122-002
C107	CAPACITOR, FIXED, ELECTROLYTIC, 20 μf, 450 VDC	0510122-002
C108	CAPACITOR, FIXED, ELECTROLYTIC, 20 μf, 450 VDC	0510122-002
C109	CAPACITOR, FIXED, ELECTROLYTIC, 20 μf, 450 VDC	0510122-002
C201	CAPACITOR, FIXED, FILM, 0.1 μf, 400 VDC	0610067-104
C202	CAPACITOR, FIXED, CERAMIC DISC, 150 pf, 1000 VDC	0401025
C203	CAPACITOR, FIXED, CERAMIC DISC, 100 pf, 1000 VDC	0401022
C204	CAPACITOR, FIXED, CERAMIC DISC, 0.0033 μf, 1000 VDC	0401051
C205	CAPACITOR, FIXED, FILM, 0.1 μf, 400 VDC	0610067-104
C206	CAPACITOR, FIXED, CERAMIC DISC, 100 pf, 1000 VDC	0401022
C207	CAPACITOR, FIXED, ELECTROLYTIC, 1000 μf, 6 VDC	0510089-020

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
C208	CAPACITOR, FIXED, ELECTROLYTIC, 8 μf, 150 VDC	0510107-001
C209	CAPACITOR, FIXED, CERAMIC DISC, 50 pf, 1000 VDC	0401016
C210	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C211	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C212	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C213	CAPACITOR, FIXED, CERAMIC DISC, 0.001 μf, 500 VDC	0401046
C214	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C215	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C216	CAPACITOR, FIXED, FILM, 0.033 μf, 400 VDC	0610067-333
C217	CAPACITOR, FIXED, ELECTROLYTIC, 1000 μf, 6 VDC	0510089-020
C218	CAPACITOR, FIXED, ELECTROLYTIC, 1000 μf, 15 VDC	0510092-020
C219	CAPACITOR, FIXED, ELECTROLYTIC, 1000 μf, 15 VDC	0510092-020
C220	CAPACITOR, FIXED, FILM, 0.1 μf, 400 VDC	0610067-104

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
C301	CAPACITOR, FIXED, FILM, 0.022 µf, 400 VDC	0610067-223
C302	CAPACITOR, FIXED, FILM, 0.1 µf, 400 VDC	0610067-104
C303	CAPACITOR, FIXED, CERAMIC DISC, 0.001 µf, 500 VDC	0401046
C304	CAPACITOR, FIXED, FILM, 0.01 µf, 400 VDC	0610067-103
C305	CAPACITOR, FIXED, CERAMIC DISC, 680 pf, 1000 VDC	0401042
C306	CAPACITOR, FIXED, ELECTROLYTIC, 1000 µf, 6 VDC	0510089-020
C307	CAPACITOR, FIXED, FILM, 0.001 µf, 400 VDC	0610098-449
C308	CAPACITOR, FIXED, FILM, 0.001 µf, 400 VDC	0610098-449
C309	CAPACITOR, FIXED, FILM, 0.05 µf, 400 VDC	0610067-503
C310	CAPACITOR, FIXED, FILM, 0.05 µf, 400 VDC	0610067-503
C311	CAPACITOR, FIXED, CERAMIC DISC, 50 pf, 1000 VDC	0401016
C312	CAPACITOR, FIXED, FILM, 0.05 µf, 400 VDC	0610067-503
C313	CAPACITOR, FIXED, FILM, 0.47 µf, 400 VDC	0610098-448

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
C314	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C315	CAPACITOR, FIXED, FILM, 0.01 μf, 400 VDC	0610067-103
C316	CAPACITOR, FIXED, FILM, 0.022 μf, 400 VDC	0610067-223
C317	CAPACITOR, FIXED, CERAMIC DISC, 500 pf, 1000 VDC	0401039
*C401	CAPACITOR, FIXED, CERAMIC DISC, 0.02 μf, 1400 VDC	0410013-001
C901	CAPACITOR, FIXED, PLASTIC, DIELECTRIC, 8 μf, 2000 VDC	0810013-001
C902	CAPACITOR, FIXED, POLYSTYRENE, DIELECTRIC, 0.1 μf, 1000 VDC	0610108-002
C903	CAPACITOR, FIXED, POLYSTYRENE, DIELECTRIC, 0.1 μf, 1000 VDC	0610108-002
C904	CAPACITOR, FIXED, METALLIZED PAPER, 0.68 μf, 50 VDC	0610099-006
C905	CAPACITOR, FIXED, CERAMIC DISC 0.01 μf, 500 VDC	0401056
CR101	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR102	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR103	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001

*C401 not used on serial numbers 1-0001 through 1-0055

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
CR104	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR105	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR106	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR107	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR108	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR109	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR110	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR111	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR112	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR113	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR114	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR115	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR116	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001

Table 4-1. List of Replacement Parts (Contd).

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
CR117	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR118	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR119	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR120	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR201	SEMICONDUCTOR DEVICE, DIODE, Type RS-6	3510022-004
CR301	SEMICONDUCTOR DEVICE, DIODE, Type 1N628	3510004
CR302	SEMICONDUCTOR DEVICE, DIODE, Type 1N628	3510004
CR303	SEMICONDUCTOR DEVICE, DIODE, Type 1N628	3510004
CR304	SEMICONDUCTOR DEVICE, DIODE, 1N714	3510042-012
CR305	SEMICONDUCTOR DEVICE, DIODE, Type 1N628	3510004
CR306	SEMICONDUCTOR DEVICE, DIODE, Type 1N628	3510004
CR501	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR502	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
CR503	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR504	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR505	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR506	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR507	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR508	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR509	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR510	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR511	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR512	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001
CR801	SEMICONDUCTOR DEVICE, DIODE, Type HC71	3510053-005
CR802	SEMICONDUCTOR DEVICE, DIODE, Type HC71	3510053-005
CR901	SEMICONDUCTOR DEVICE, DIODE, Type CER71A	3510053-001

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
D801	CHOPPER, ELECTRO-MECHANICAL, SPDT, 6.3 VAC, 60 CPS, 86Ω	6310018-001
DS201	LAMP, NEON, INDICATOR, Type NE-2	1704151
DS901	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS902	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS903	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS904	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS905	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS906	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
DS907	LAMP, NEON, INDICATOR, Type NE-2 in assembly	1710152-002
F901	FUSE, CARTRIDGE, 1.5 amp, SLO-BLO	1710040-122
J901	CONNECTOR, ELECTRICAL, RECEPTACLE, 12-contact	1310106-004
J902	CONNECTOR, ELECTRICAL, RECEPTACLE, 9-contact	1310106-003
K301	RELAY, ARMATURE 4 form "C" closures, 10K	3710034-001
K901	RELAY, ARMATURE, SPDT (3 sets), 28 VDC, 500Ω	3710006-008

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
P901	CONNECTOR, ELECTRICAL, PLUG, 12-contact	1310105-004
P902	CONNECTOR, ELECTRICAL, PLUG, 9-contact	1310105-003
Q301	TRANSISTOR, Type 2N1373	7210039-005
Q302	TRANSISTOR, Type 2N1373	7210039-005
Q303	TRANSISTOR, Type 2N1373	7210039-005
Q304	TRANSISTOR, Type 2N1373	7210039-005
Q305	TRANSISTOR, Type 2N169	7210017-169
R101	RESISTOR, FIXED, COMPOSITION, 22K, 2W, 5%	0310032-223
R102	RESISTOR, FIXED, COMPOSITION, 4.7K, 1W, 5%	0310031-472
R103	RESISTOR, FIXED, COMPOSITION, 820 Ω, 2W, 5%	0310032-821
R104	RESISTOR, FIXED, COMPOSITION, 15K, 1W, 5%	0310031-153
R105	RESISTOR, FIXED, COMPOSITION, 470Ω, 1W, 5%	0310031-471
R106	RESISTOR, FIXED, COMPOSITION, 10K, 2W, 5%	0310032-103
R107	RESISTOR, FIXED, COMPOSITION, 39K, 1W, 5%	0310031-393
R108	RESISTOR, FIXED, COMPOSITION, 470Ω, 1W, 5%	0310031-471

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R109	RESISTOR, FIXED, COMPOSITION, 470Ω, 1W, 5%	0310031-471
R110	RESISTOR, FIXED, WIRE-WOUND, 500Ω, 5W, 10%	5110010-028
R111	RESISTOR, FIXED, COMPOSITION, 330K, 2W, 5%	0310032-334
R112	RESISTOR, FIXED, COMPOSITION, 330K, 2W, 5%	0310032-334
R113	RESISTOR, FIXED, WIRE-WOUND, 4Ω, 5W, 10%	5110010-005
R114	RESISTOR, FIXED, WIRE-WOUND, 10K, 10W, 10%	5110016-103
R115	RESISTOR, FIXED, COMPOSITION, 470Ω, 1W, 5%	0310031-471
R201	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R202	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R204	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	0310030-224
R205	RESISTOR, FIXED, COMPOSITION, 5.6K, 1/2W, 5%	0310030-562
R206	RESISTOR, FIXED, COMPOSITION, 4.7M, 1/2W, 5%	0310030-475
R207	RESISTOR, FIXED, COMPOSITION, 680K, 1/2W, 5%	0310030-684

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R208	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R209	RESISTOR, FIXED, COMPOSITION, 1.5M, 1/2W, 5%	0310030-155
R210	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R211	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	0310030-473
R212	RESISTOR, FIXED, COMPOSITION, 120K, 1W, 5%	0310031-124
R213	RESISTOR, FIXED, COMPOSITION, 82K, 1W, 5%	0310031-823
R214	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R215	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	0310030-224
R216	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	0310030-106
R217	RESISTOR, FIXED, COMPOSITION, 3.3K, 1/2W, 5%	0310030-332
R218	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R219	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R220	RESISTOR, FIXED, COMPOSITION, 3.3K, 1/2W, 5%	0310030-332

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R221	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	0310030-335
R222	RESISTOR, FIXED, COMPOSITION, 470K, 1/2W, 5%	0310030-474
R223	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	0310030-224
R224	RESISTOR, FIXED, COMPOSITION, 470K, 1/2W, 5%	0310030-474
R225	RESISTOR, FIXED, COMPOSITION, 150K, 1/2W, 5%	0310030-154
R226	RESISTOR, FIXED, COMPOSITION, 820Ω, 1/2W, 5%	0310030-821
R227	RESISTOR, FIXED, COMPOSITION, 3.3M, 1/2W, 5%	0310030-335
R228	RESISTOR, FIXED, COMPOSITION, 2.7M, 1/2W, 5%	0310030-275
R229	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	0310030-224
R230	RESISTOR, FIXED, COMPOSITION, 820K, 1/2W, 5%	0310030-824
R231	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	0310030-106
R301	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	0310030-106
R302	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R303	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	0310030-473
R304	RESISTOR, FIXED, COMPOSITION, 6.8M, 1/2W, 5%	0310030-685
R305	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R306	RESISTOR, FIXED, COMPOSITION, 1.5M, 1/2W, 5%	0310030-155
R307	RESISTOR, FIXED, COMPOSITION, 5.6K, 1/2W, 5%	0310030-562
R308	RESISTOR, FIXED, COMPOSITION, 6.8K, 1W, 5%	0310031-682
R309	RESISTOR, FIXED, COMPOSITION, 3.3K, 1/2W, 5%	0310030-332
R310	RESISTOR, FIXED, COMPOSITION, 120K, 2W, 5%	0310032-124
R311	RESISTOR, FIXED, COMPOSITION, 82K, 2W, 5%	0310032-823
R312	RESISTOR, FIXED, COMPOSITION, 47K, 1W, 5%	0310031-473
R313	RESISTOR, FIXED, COMPOSITION, 390K, 1W, 5%	0310031-394
R314	RESISTOR, FIXED, COMPOSITION, 100Ω, 1/2W, 5%	0310030-101
R315	RESISTOR, FIXED, COMPOSITION, 68K, 1/2W, 5%	0310030-683

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R316	RESISTOR, VARIABLE, COMPOSITION, 5K, 1/4W, 20%, linear	5010179-007
R317	RESISTOR, FIXED, COMPOSITION, 8.2K, 1/2W, 5%	0310030-822
R318	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	0310030-473
R319	RESISTOR, FIXED, COMPOSITION, 3.9K, 1/2W, 5%	0310030-392
R320	RESISTOR, FIXED, COMPOSITION, 18K, 1/2W, 5%	0310030-183
R321	RESISTOR, FIXED, COMPOSITION, 15K, 1/2W, 5%	0310030-153
R322	RESISTOR, FIXED, COMPOSITION, 22K, 1/2W, 5%	0310030-223
R323	RESISTOR, FIXED, COMPOSITION, 6.8K, 1/2W, 5%	0310030-682
R324	RESISTOR, FIXED, WIRE-WOUND, 10K, 20W, 5%	5102100
R325	RESISTOR, FIXED, COMPOSITION, 220Ω, 1/2W, 5%	0310030-221
R326	RESISTOR, FIXED, COMPOSITION, 15K, 1/2W, 5%	0310030-153
R327	RESISTOR, FIXED, COMPOSITION, 2.2K, 1/2W, 5%	0310030-222
R328	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105

Table 4-1. List of Replacement Parts (Cont'd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R329	RESISTOR, FIXED, COMPOSITION, 82Ω, 1/2W, 5%	0310030-820
R330	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R331	RESISTOR, FIXED, COMPOSITION, 2.2K, 1/2W, 5%	0310030-222
R332	RESISTOR, FIXED, COMPOSITION, 39K, 1/2W, 5%	0310030-393
R333	RESISTOR, FIXED, COMPOSITION, 2.2K, 1/2W, 5%	0310030-222
R334	RESISTOR, FIXED, COMPOSITION, 39K, 1/2W, 5%	0310030-393
R335	RESISTOR, FIXED, COMPOSITION, 10K, 1/2W, 5%	0310030-103
R336	RESISTOR, FIXED, COMPOSITION, 10K, 1/2W, 5%	0310030-103
R337	RESISTOR, FIXED, COMPOSITION, 10K, 1/2W, 5%	0310030-103
R338	RESISTOR, FIXED, COMPOSITION, 1K, 1/2W, 5%	0310030-102
R339	RESISTOR, FIXED, COMPOSITION, 270Ω, 1/2W, 5%	0310030-271
R340	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R341	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R342	RESISTOR, FIXED, COMPOSITION, 39K, 2W, 5%	0310032-393
R343	RESISTOR, FIXED, COMPOSITION, 560Ω, 1/2W, 5%	0310030-561
R344	RESISTOR, FIXED, COMPOSITION, 2.2M, 1/2W, 5%	0310030-225
R345	RESISTOR, FIXED, COMPOSITION, 180K, 2W, 5%	0310032-184
R346	RESISTOR, FIXED, COMPOSITION, 220K, 1W, 5%	0310031-224
R347	RESISTOR, FIXED, COMPOSITION, 56K, 1W, 5%	0310031-563
R348	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	0310030-106
R349	RESISTOR, FIXED, COMPOSITION, 39K, 2W, 5%	0310032-393
R350	RESISTOR, FIXED, COMPOSITION, 180K, 1W, 5%	0310031-184
R351	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	0310030-473
R352	RESISTOR, VARIABLE, COMPOSITION, 10K, 1/4W, 20%, linear	5010179-008
R353	RESISTOR, FIXED, COMPOSITION, 470K, 1/2W, 5%	0310030-474
R354	RESISTOR, FIXED, COMPOSITION, 6.8M, 1/2W, 5%	0310030-685

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R355	RESISTOR, FIXED, COMPOSITION, 47K, 1/2W, 5%	0310030-473
R356	RESISTOR, FIXED, COMPOSITION, 33K, 1/2W, 5%	0310030-333
R357	RESISTOR, FIXED, COMPOSITION, 33K, 1/2W, 5%	0310030-333
R401	RESISTOR, VARIABLE, WIRE-WOUND, 10Ω, 1W, 1.28%	5010200-002
R402	RESISTOR, VARIABLE, WIRE-WOUND, 100Ω, 1W, 0.68%	5010200-004
R403	RESISTOR, VARIABLE, WIRE-WOUND, 1K, 1W, 0.34%	5010200-012
R404	RESISTOR, VARIABLE, WIRE-WOUND, 10Ω, 1W, 1.28%	5010200-002
R406	RESISTOR, FIXED, WIRE-WOUND, 1Ω, 1/2W	5210100-011
R407	RESISTOR, FIXED, WIRE-WOUND, 2Ω, 1/2W	5210100-012
R408	RESISTOR, FIXED, WIRE-WOUND, 4Ω, 1/2W	5210100-013
R409	RESISTOR, FIXED, WIRE-WOUND, 4Ω, 1/2W	5210100-013
R410	RESISTOR, FIXED, WIRE-WOUND, 10Ω, 1/2W	5210100-008
R411	RESISTOR, FIXED, WIRE-WOUND, 20Ω, 1/2W	5210100-009

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R412	RESISTOR, FIXED, WIRE-WOUND, 40Ω 1/2W	5210100-010
R413	RESISTOR, FIXED, WIRE-WOUND, 40Ω 1/2W	5210100-010
R414	RESISTOR, FIXED, WIRE-WOUND, 100Ω, 1/2W	5210100-005
R415	RESISTOR, FIXED, WIRE-WOUND, 200Ω, 1/2W	5210100-006
R416	RESISTOR, FIXED, WIRE-WOUND, 400Ω, 1/2W	5210100-007
R417	RESISTOR, FIXED, WIRE-WOUND, 400Ω, 1/2W	5210100-007
R418	RESISTOR, FIXED, WIRE-WOUND, 1K, 1/2W	5210100-002
R419	RESISTOR, FIXED, WIRE-WOUND, 2K, 1/2W	5210100-003
R420	RESISTOR, FIXED, WIRE-WOUND, 4K, 1/2W	5210100-004
R421	RESISTOR, FIXED, WIRE-WOUND, 4K, 1/2W	5210100-004
R422	RESISTOR, FIXED, PRECISION, 9.995K, 0.03%, non-inductive	5210076-007
R423	RESISTOR, VARIABLE, WIRE-WOUND, 10Ω, 1W, 1.28%	5010200-002
R424	RESISTOR, FIXED, PRECISION, 19.99K, 0.03%, non-inductive	5210076-008

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R425	RESISTOR, VARIABLE, WIRE-WOUND, 20Ω, 1W, 1.27%	5010200-009
R426	RESISTOR, VARIABLE, WIRE-WOUND, 50Ω, 1W, 0.89%	5010200-008
R427	RESISTOR, FIXED, PRECISION, 39.98K, 0.03%, non-inductive	5210076-009
R428	RESISTOR, FIXED, PRECISION, 39.98K, 0.03%, non-inductive	5210076-009
R429	RESISTOR, VARIABLE, WIRE-WOUND, 50Ω, 1W, 0.89%	5010200-008
R430	RESISTOR, VARIABLE, WIRE-WOUND, 100Ω, 1W, 0.68%	5010200-004
R431	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R432	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R433	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R434	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R435	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R436	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R437	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R438	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R439	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R440	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R441	RESISTOR, FIXED, PRECISION, 99.95K, 0.03%, non-inductive	5210076-010
R442	RESISTOR, VARIABLE, WIRE-WOUND, 500Ω, 1W, 0.44%	5010200-011
R443	RESISTOR, VARIABLE, WIRE-WOUND, 500Ω, 1W, 0.44%	5010200-011
R444	RESISTOR, VARIABLE, WIRE-WOUND, 200Ω, 1W, 0.56%	5010200-010
*R445	RESISTOR, FIXED, PRECISION, Selected value	7813950
R446	RESISTOR, FIXED, PRECISION, 5.895K, 0.03%, non-inductive	5210076-013
R447	RESISTOR, FIXED, PRECISION, 58.95K, 0.03%, non-inductive	5210076-014
R448	RESISTOR, FIXED, PRECISION, 589.5K, 0.03% non-inductive	5210076-015
R459	(FACTORY SELECTED; PART OF S401 ASSEMBLY)	
R501	RESISTOR, FIXED, COMPOSITION, 560K, 2W, 5%	0310032-564

*Used on serial numbers 1-0001 through 1-0055

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R502	RESISTOR, FIXED, COMPOSITION, 560K, 2W, 5%	0310032-564
R503	RESISTOR, FIXED, COMPOSITION, 560K, 2W, 5%	0310032-564
R504	RESISTOR, FIXED, COMPOSITION, 560K, 2W, 5%	0310032-564
R801	RESISTOR, FIXED, COMPOSITION, 270K, 1/2W, 5%	0310030-274
R802	RESISTOR, FIXED, COMPOSITION, 220Ω, 1/2W, 5%	0310030-221
*R802	RESISTOR, FIXED, COMPOSITION, 270Ω, 1/2W, 5%	0310030-271
R803	RESISTOR, FIXED, COMPOSITION, 560K, 1/2W, 5%	0310030-564
*R803	RESISTOR, FIXED, COMPOSITION, 220K, 1/2W, 5%	0310030-224
*R804	RESISTOR, FIXED, COMPOSITION, 330K, 1/2W, 5%	0310030-334
*R805	RESISTOR, FIXED, COMPOSITION, 22K, 1/2W, 5%	0310030-223
R806	RESISTOR, FIXED, COMPOSITION, 10M, 1/2W, 5%	0310030-106
R807	RESISTOR, FIXED, COMPOSITION, 22K, 1/2W, 5%	0310030-223
R808	RESISTOR, VARIABLE, COMPOSITION, 10K, 1/2W, 10%	5010181-003

*R802, R803, R804, R805 used on serial numbers 1-0001 through 1-0055

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
*R809	RESISTOR, FIXED, COMPOSITION, 100Ω, 1/2W, 5%	0310030-101
*R810	RESISTOR, FIXED, COMPOSITION, 560K, 1/2W, 5%	0310030-564
*R811	RESISTOR, VARIABLE, COMPOSITION, 10K, 1/2W, 10%	5010181-003
*R812	RESISTOR, FIXED, COMPOSITION, 47Ω, 1/2W, 5%	0310030-470
*R813	RESISTOR, FIXED, COMPOSITION, 820K, 1/2W, 5%	0310030-824
*R814	RESISTOR, VARIABLE, COMPOSITION, 10K, 1/2W, 10%	5010181-003
R901	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R902	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R903	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R904	RESISTOR, FIXED, COMPOSITION, 1M, 1/2W, 5%	0310030-105
R906	RESISTOR, FIXED, COMPOSITION, 10Ω, 1/2W, 5%	0310030-100
R910	RESISTOR, FIXED, PRECISION, 600Ω, 1/2W, 1%	5210072-025
R911	RESISTOR, FIXED, PRECISION, 300Ω, 1/2W, 1%	5210072-001

*R809 through R814 not used on serial numbers 1-0001 through 1-0055

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
R912	RESISTOR, FIXED, PRECISION, 200Ω, 1/2W, 1%	5210072-027
R913	RESISTOR, FIXED, PRECISION, 120Ω, 1/2W, 1%	5210072-023
R914	RESISTOR, FIXED, COMPOSITION, 220K, 2W, 5%	0310032-224
R915	RESISTOR, FIXED, COMPOSITION, 270K, 2W, 5%	0310032-274
R916	RESISTOR, FIXED, COMPOSITION, 100Ω, 2W, 5%	0310032-101
R917	RESISTOR, FIXED, COMPOSITION, 10Ω, 1/2W, 5%	0310030-100
R918	RESISTOR, FIXED, COMPOSITION, 10K, 1/2W, 5%	0310030-103
S401	SWITCH, ASSEMBLY, Special	7813058-001
S402	SWITCH, ROTARY, 1P11T, 3-Deck	6210060-001
S403	SWITCH, ROTARY, 1P11T, 3-Deck	6210060-001
S404	SWITCH, ROTARY, 1P11T, 3-Deck	6210060-001
S405	SWITCH, ROTARY, 1P11T, 3-Deck	6210060-001
S406	SWITCH, ROTARY, 1P11T, 3-Deck	6210060-001
S407	SWITCH, ROTARY, 1P11T, 4-Deck	6210074-001
S901	SWITCH, ROTARY, SPST, Modified	6210018-005
S902	SWITCH, ROTARY, SPST, Modified	6210018-006

Table 4-1. List of Replacement Parts (Contd)

CIRCUIT SYMBOL	DESCRIPTION	KIN TEL PART NO.
S903	SWITCH, ROTARY, SP4T, 1-Deck	6210062-001
S904	SWITCH, ROTARY, 3P3T, 2-Deck	6210063-001
S905	SWITCH, ROTARY, 3P3T, 1-Deck	6210061-001
T901	TRANSFORMER, POWER, Special	6510094-001
T902	TRANSFORMER, Special	6510108-001
V201	TUBE, ELECTRONIC, Type 5751	7302812
V202	TUBE, ELECTRONIC, Type 6AU6A	7010041-001
V203	TUBE, ELECTRONIC, Type 6AU6A	7010041-001
V204	TUBE, ELECTRONIC, Type 6AU6A	7010041-001
V301	TUBE, ELECTRONIC, Type 6CB6	7002773
V302	TUBE, ELECTRONIC, Type 6CB6	7002773
V303	TUBE, ELECTRONIC, Type 6AU8	7007118
V901	TUBE, ELECTRONIC, Type 6889	7010040-001

Recommended Spare Parts for KIN TEL
Model 303 DC Voltage Standard

KIN TEL PART NO.	DESCRIPTION	KIT NUMBER 7813-PK001 STOCK LEVEL 1 unit	KIT NUMBER 7813-PK005 STOCK LEVEL 5 units	KIT NUMBER 7813-PK025 STOCK LEVEL 25 units
0510059	Capacitor, electrolytic, 20/20 µf, 150V	1	2	5
0510089-021	Capacitor, electrolytic, 1000 µf, 6V	3	9	15
0510092-020	Capacitor, electrolytic, 1000 µf, 15V	2	6	10
0510121-006	Capacitor, electrolytic, 40/20 µf, 450V	1	2	5
0510122-002	Capacitor, electrolytic, 20 µf, 450V	2	5	15
0810013-001	Capacitor, plastic, 8 µf, 2KV	1	2	5
3510004	Semiconductor, diode, type 1N628	2	4	10
3510022-004	Semiconductor, diode, type RS-6	1	2	5
3510042-012	Semiconductor, diode, type 1N714	1	2	5
3510053-001	Semiconductor, diode, type CER71A	16	40	100
3510053-005	Semiconductor, diode, type HC71	2	4	10
6310018-001	Chopper, SPDT, 6.3V, 60 cps, 86Ω	1	1	3
6510094	Transformer, power	0	0	1
7010041-001	Tube, electron, type 6AU6A	2	5	10
7002773	Tube, electron, type 6CB6A	1	2	5
7007118	Tube, electron, type 6AU8A	1	2	5
7010040-001	Tube, electron, type 6889	1	1	2
7210017-169	Transistor, type 2N169	1	2	5
7210039-005	Transistor, type 2N1373	4	8	20

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Recommended Spare Parts for KIN TEL
Model 303 DC Voltage Standard (Contd)

PART NO.	DESCRIPTION	STOCK LEVEL		
		1 unit	5 units	25 units
7302812	Tube, electron, type 5751	1	2	5
7813091-001	Assembly, Reference Unit	0	0	1
7813065-001	Assembly, Power Tube and Relay	0	0	1
7813101-001	Assembly, Power Supply	0	0	1
7813201-001	Assembly, Carrier and Wideband Amplifiers	0	0	1
7813301-001	Assembly, DC Output Amplifier	0	0	1
7813501-001	Assembly, High Voltage Power Supply	0	0	1

WARRANTY

COHU ELECTRONICS, INC., Kin Tel Division, warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by COHU examination to have been defective within one year (90 days for batteries, fuses, transistors and tubes) from date of shipment to the original purchaser. All warranty repairs will be performed at the factory or as otherwise authorized by COHU in writing. Transportation charges shall be prepaid by purchaser.

This warranty does not extend to COHU equipment subjected to misuse, accident, neglect or improper application; nor repaired or altered by other than COHU or those authorized by COHU in writing.

This warranty is in lieu of all other warranties express or implied. COHU shall not be liable for collateral or consequential damages.

For customer convenience, service departments are maintained throughout the United States by COHU Field Engineering Representatives.

COHU
ELECTRONICS, INC
KIN TEL DIVISION

FORM NO. S-212 (May 1, 1962)

5725 Kearny Villa Road

San Diego 12, California

5 MA LOAD @ 1V = 200Ω

10 " " " = 100Ω

15 " " " = 66.6Ω

25 " " " = 40.0Ω

93403